research-based education 2016

Volume One
The papers in this book include the proceedings of aae2016 conference held in London in April 2016. The papers were blind-reviewed and copy-edited but they only reflect the authors’ opinions. Inclusion in this publication does not necessarily constitute endorsement by the editors, the association of architectural educators (aae) or The Bartlett School of Architecture, UCL.

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aae2016

Hosted by The Bartlett School of Architecture, UCL in collaboration with the association of architectural educators (aae), aae2016 is an International Peer Reviewed Conference on ‘Research-Based Education’ which runs from 7 to 9 April 2016.

The aae2016 is part of Bartlett 175, an exciting series of events celebrating the 175 years of architectural education at UCL.

At a pivotal time for architectural education, this conference will bring together global innovators in education, research and practice to interrogate the diverse natures and interrelationships between these realms as they relate to architecture, and to discuss how and why they may evolve over the coming century. The conference will include sessions on the themes of Curiosity, Risk, Participation and Production.
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It is especially apt that UCL, 190 years after its foundation, is hosting the association of architectural educators conference. UCL was founded on the heels of the enlightenment with the radical mission to improve the lot of all through education and scholarship. The appointment in 1841 of Thomas Leverton Donaldson, a founder just two years previously of the RIBA, to the first Chair of Architecture in a British University was one in a series of UCL ‘firsts’: the first Chairs of Chemistry, Engineering and Chinese; the first to admit those of the Jewish faith; the first to admit women on the same terms as men. All of these flew in the face of the medieval and religious scholastic foundations of the two English universities.

Few at that time could have foreseen just how radical the study of architecture would become, and I would argue that today this understanding is still not mainstream. Here I only have space to say first why I think architecture is radical, and so why its education is also, and then to give some examples of things we are doing at The Bartlett to extend that tradition. I am confident that the conference will give additional opportunities to explore these issues.

The enlightenment marked a change in the way that people conceived of many things, not only the relation between the physical and material world and that of theories and ideas, but also the relations between people, politics and the legitimacy of government. This kind of change is a remarkable characteristic of human culture and one that was perhaps first recognised in the 20th century with the psychological turn in social science through the concept of inter-subjectivity. Briefly, this refers to those aspects of our subjective understanding or the world that must be shared between people as the assumptions that allow common social action to take place. Thus Francis Bacon’s empiricism, Descartes’ logic, Spinoza’s antiteleology and Locke’s concerns with political legitimacy all came together to create a new inter-subjective set of norms and assumptions on which, first, Western science, and next, the modern state were built.

Roll forward to today. It is now beginning to be understood that the built environment forms an ‘inter-objective’ realm, complementary to the inter-subjectivity of ideas, creating as it does a layer of objective constraint on human action, association and transaction. There
are some who argue that it was the invention of proto-urban form that led to the first flowering of civilisation in the ancient near east, the invention of settled agriculture, writing, money and of state formation. If this is so, then it is the role of the radical architect and planner as much as the philosopher to invent new possibilities for social formation.

How then does this work? Every act of construction – building walls and enclosures, streets and thresholds – creates a potential for human occupation, movement and interaction, and in doing so reduces other potentials. Construction does not uniquely specify social interactions, as other factors are also involved: patterns of social function and land use, the regular daily cycles of activity, social rules on space use or ownership and so forth; but spatial design plays a powerful role in structuring the field of possibility for social relations. There is no doubt about the complexity of the interactions of all these dimensions, as well as of the feedback from the social that affects the configuration of the built environment. There is equally little doubt about the feedback from the spatial onto the social and economic. The whole is entailed into a complex and emergent system in which is essentially ‘lived and behaved’ for the most part subconsciously.

The mainly subconscious enactment in the spatial world out of which social structures emerge is similar to the subconsciousness of our acceptance of intersubjective assumptions and norms in the realm of thought. It is precisely the fact that architecture and the built environment is ‘lived’ subconsciously rather than ‘thought about’ consciously that creates the specific challenge of architectural education. The architect must learn to intuit the emergent outcomes of new and never before constructed environments on patterns of social behavior and interaction, and to do so both through use of their own subconscious intuition, but also to be consciously aware and reflective on these. The architect as a reflective practitioner, like a tennis player, must train to act without thinking, but at the same time to think completely strategically.

In order to challenge existing assumptions we are exploring new models of architectural education. First, the assumption that the architect’s prime responsibility is to their client. We are working to develop an ethical code for the built environment professions that places priority instead on responsibility to society at large and future generations. This will be fundamental to the delivery of a more sustainable world. Second, we are working to challenge disciplinary divides between areas of professional knowledge. For example we are developing a new undergraduate program MEng in Engineering for Architectural Design, linking between The Bartlett’s School of Architecture, its Institute of Environmental Design and Engineering and The Department of Civil, Environmental and Geomatic Engineering. Third, the assumption of individual authorship in creative practice. We are learning from educational methods in time-based and performing arts to investigate whether new models of collaborative creativity can be developed for architectural design. We are at an early stage in plans for all three areas of work.
Introduction

Professor Bob Sheil
Director, The Bartlett School of Architecture

The form, purpose, and direction of architectural education generates continual debate, and in our time probably more so than in any period before. Fundamentally this stems from its creative core, an energy that is constantly buzzing, seeking renewal, opening doors, and responding to change. In addition, its dual role as a structure to prepare students for practice, and a terrain that offers up the subject at large, is in itself a chemical exchange. Both sides of this challenge are on a spectrum that extends from the sharp perimeters of each domain to the agitated blur of spaces they both occupy. These perpetual reactions are what make architectural education one of the most exciting, demanding, influential and significant enquiries of human learning and development.

In the UK, the undergraduate programme itself is one of the most powerful transformative agencies in higher education as a whole, generating graduates of extraordinary diversity, ability, flexibility and insight. The bridge they cross into their first exposure to industry and the profession is not always smooth, but it is without doubt a pivotal experience of transition from learning to application that industry profits from in a myriad of ways. The year – or two years – out, and subsequent postgraduate education, followed by a further stint in professional learning and development, add up to a long and challenging path that is increasingly difficult to traverse.

The dominant issues fuelling debate today surround longevity, cost, and accessibility. Skill is another key issue. Institutions of governance, regulation, policy and education are engaged in fraught and complex calculation on how best to tackle the many conundrums that lie ahead. Meanwhile, the entire industry of architectural education is predominantly underpinned by two core communities, teachers and researchers, neither of whom always get a look-in on the big decisions, even though the vast majority operate across the spectrum of practice, education and research every day.

We are extremely pleased to be hosting the association of architectural educators conference at such a time. aae represents the individuals and experiences that occupy the coalface of our activity. Year in, year out, they explore, develop, imagine, and read the circumstances in which we operate and respond with insightful approaches. They
write the briefs that operate as vessels of learning, provocation, exploration and delivery. They spin an inordinate number of plates with great ingenuity, on top of which they act as pastoral carers to their closest audience. Behind the scenes they develop their own positions as either researchers or practitioners, or in many cases both. What this demonstrates clearly is how the environment of education is a profound generator that defines and shapes architectural knowledge and expertise, complementing industry and practice in ways that are vital and unique.

It is timely, therefore, that aae2016 is devoted to recognising this status under the theme of ‘research-based education’, a defining characteristic that applies to architecture in ways that need far greater recognition than it presently enjoys. Research-based education in architecture is extraordinarily rich and diverse, as well as innovative. It is a field of learning where research and education started at the same time as the profession was formed. At UCL this year, we are celebrating 175 years since the appointment of our first Professor in Architecture in 1841, Thomas Leverton Donaldson, a founder of the RIBA when it was established in 1836. The year’s events range from academic conferences to a special publication produced with the Architectural Review, to exhibitions and alumni activities. We are grateful to supporters within UCL and across industry, particularly the aae2016 Main Title sponsors Scott Brownrigg, for enabling us to host the event.

In his inaugural address, Donaldson declared:

“We are all, in fact, in a state of transition… We are wandering in a labyrinth of experiments … thus creating a new and peculiar style. This movement has placed the schools of all countries in a state of great uncertainty; as yet we have no fine leading principle as a guiding star”.

On this note of confident recognition that architectural education is inextricably bound to the notion of research, we welcome you to this conference, its proceedings and its debate.
The aae (association of architectural educators) was founded in September 2011. A collaboration of academics from various institutions in the UK we established the following aims through which we direct our activities. These aims are instrumental to our agenda within architectural education.

THE ASSOCIATION OF ARCHITECTURAL EDUCATORS (AAE) AIMS:

1. To develop, support and represent communities of practice and learning in architectural education in the U.K. and Ireland.
2. To foster inclusive dialogues between the aae community, students and employers, and educational and professional bodies.
3. To encourage research and scholarship of teaching and learning in architectural education through critical and reflective discourse.
4. To promote the value, richness, quality, and diversity inherent in architectural education.

The aae benefits from a group of enthusiastic members with representation from schools based in the north, south, east and west, we are fortunate to have support and input from a rich community of architectural educators. This helps us to achieve our three key outputs, including hosting an annual aae international conference, the production of the aae journal Charrette and to support the committee working to develop the organisation itself.

THE AAE STEERING COMMITTEE’S MEMBERS (2015-16):

• Chair & Co-Treasurer: Hannah Vowles, Birmingham City University
• Vice Chair: Dan Jary, University of Sheffield
• Secretary & Co-Treasurer: Victoria Farrow, Birmingham City University
• Web coordinator: Julian Williams, University of Westminster
• Charrette editor: Professor Ruth Morrow, Queen’s University Belfast
• Charrette assistant editor (formerly series editor): James Benedict Brown, De Montfort University
TO DATE THE AAE HAS HOSTED TWO CONFERENCES:

In April 2013 we formally launched the association of architectural educators together with Charrette at Nottingham Trent University. This event was followed by our second conference at the University of Sheffield in September 2014. Both were very successful and have helped us to sustain material for the journal but also have enabled us to remain engaged and contributing to the architectural community that support us. We are thrilled that The Bartlett has been able to host our third conference in line with their 175th anniversary and very much look forward to the event.

ADDITIONAL ACTIVITIES INCLUDE:

aae and Vectorworks scholarship programme
This programme provided free software licenses to staff, students and schools in-house along with a range of other benefits such as a support page, workshops, and access to a range of resources online for staff and students.

aae BIM camps
The BIM camps look to support architectural educators and their students through the provision of knowledge and guidance in BIM. The first aae BIM camp was hosted at Birmingham City University in January 2016 and we are now looking to provide further BIM camps to other member schools.

National Conference on the Beginning Design Student
Our links with NCBDS together with sponsors including Scott Brownrigg and Vectorworks allow us to tap further into the international communities of architectural educators and also further afield. As a growing organisation we welcome your support.

Thank you for being a part of our development.
Keynote

Izaskun Chinchilla

Curiosity

The goal that has guided both the research and drafting of this intervention has been to be truly useful to architects and designers who, by self conviction or through third parties, want to devise and implement a more ecological or more social development of architecture or design products. My intervention will propose to these professionals a new design manifesto: a deeper application of ecological and social principles to architecture would change everything; it wouldn´t be a partial change, it would mean a revolution. Under this new declaration, a closer link between ecology, sociology and innovation is set; making ecological architecture and design necessary to impact change, progress, and achieve higher levels of organization. To achieve greater success with fewer resources signifies, therefore, to innovate.

To describe how a profession may face a revolution, this intervention has drawn on the book published in 1962, and extended in 1969, ‘The Structure of Scientific Revolutions’ by Thomas Kuhn. This book has provided the instrumental definition of key terms such as architecture, revolution and normal science, which have influenced the structure of chapters and helped to identify the details of architectural work and its socialization within the professional guild. The title of this intervention aims to be an explicit recognition of the importance of terms as curiosity, discovery and invention in Kuhn’s book.
In general, the intervention is aimed at architects whose training in ecology and innovation has not played an essential role. Therefore, part of this acknowledgment and the description of design practices are common. Descriptions of how architects design without pursuing ecological and innovative maxims will be abundant. These descriptions reveal, through analysis and diagnosis, design principles which play an important role in structuring the professional practice, and which, however, are applied informally; without specific hypotheses or methodological justification. What role do masterpieces or visual references in teaching and design practices play? How do architects use terms like elegance, consistency and sincerity when they speak about the virtues of their projects? What challenges, within a project, are formulated as problems with solutions? Which methodological aspects are never mentioned? That these informal procedures are precisely those which more decisively contribute to limit the penetration and impact of the ecological paradigm is one of the hypotheses offered to the audience.

In addition to this individual utility as a vehicle for the transformation of design methods, the intervention aims to contribute to a collective and institutional debate on the present challenges of pedagogy, evaluation and implementation of the architecture project. The collective utility that guides the drafting of the intervention is to transform into new professional opportunities the challenges arising from the ecological crisis and to encourage architects, and the institutions they lead, benefiting from the resources and incentives linked to innovation. To reach this dual purpose, individual and collective, I will try to describe a structure, which may make institutions more capable of promoting ecological practices and innovative design. What would be the political implications of a collective change to design methodologies? How do institutions contribute to the establishment of a collective speculation of what the ecological architecture and city are? What role do we bestow upon images? And upon social agendas?

Overall, the methodological reflection of the proposal is articulated in the format of a reflection to design new pedagogic plans. That training plan intends to be useful, as already mentioned, to recycle professionals trained with different perspectives. But an equally important objective is to contribute to the definition of basic principles for a new undergraduate and social role of the architect and designer profession.
In this paper I will argue that top-down tactics of delivering knowledge in architectural education should be considered out-dated, ineffective and unproductive, and that research-based education must adopt a more bottom-up, and poetic, approach towards research-led education. This supposition is based on the grounds that contemporary architectural industry is unthinkable without computational aid, and that today’s teens and pre-teens are the first officially digitally-educated generation. Practice is already reacting to the shifting paradigms of a digitalized world, and school education already presumes literacy and spontaneity with information and communications technologies. Consequently, it seems unavoidable that higher education institutions should be prepared to accommodate these very students who are used to interact with digital technologies and computer-based learning, and to allow them to thrive thanks to new tools and technologies and capitalise on the emergence of collaborative intelligence, network learning and distributed problem-solving systems.

TOP-DOWN PEDAGOGICS

A priest on a pulpit; a judge on a raised bench; a tennis umpire in a high chair – these are only a few examples of how to literally deliver knowledge top-down. Not surprisingly, this spatial construct pretends to be capable of teaching what is right and what is wrong. It is a constitutive part of architectural education to consider and to discuss true and false ways of doing things. For example, in terms of building construction, how to do suitable details in order to insulate buildings properly, erect decent structures to make it robust and sound, and find virtuous ways of complying with norms and regulations. But also how to avoid incorrect sizing of rooms, erroneous financial planning and inappropriate material choices and so on. However, when it comes to architectural design, the issue of good and bad, right and wrong, true and false becomes extremely complicated. A huge amount of decision-making is not quantifiable, not specifiable, and arguably not teachable.

Therefore, most top-down criteria and evaluation protocols that have been put in place to categorise, analyse, test, and criticise architecture, for example function (programme, programs), order (form, style) or process (narratives, protocols), cannot but fail to withstand critical observation. Function as substantiation rationale for example does not really provide a valid analytical system. It is right that “the behaviour of people, their judgments and assessments as ‘consumers’ of the building, the characteristics of their spontaneous alterations to the spaces, the symbolic situations they interpose into them, the texts of decisions they make” belong to the “operational...
knowledge” of the architect and are to be absorbed directly into the design processes, as argued by M.R. Savchenko (1980 pp. 31-39). The architect is to “define the characteristics whose value it will be necessary to measure” and to consider the “relationships and connections between the parameters themselves”. But both the functional parameters, to Savchenko the “direct measurements” of a building (“that is of its spaces, the architectural activities it accommodates, and of the consumers involved”) and the functional properties, the “indirect measurements of different readings, meanings and reactions inferred by an ‘intermediary’ consumer” (a “user who enters into the ‘make-up’ of the actual buildings”; some overlaid “symbolic situations”) end up being too ephemeral to predict, with functions and programmes changing too often and too radically to become absolute. One consequence of this variability and unpredictability is that parameters and properties as attributes become too fixed, and inadequate as evaluation criteria.

Perhaps this is why “performativity” seems to have replaced the word “function” in many architectural schools. Method-based processes and techniques surely make invention and originality possible, as they enable the implementation of technology, materiality and rigour, advancing the discipline’s knowhow. Nevertheless, they are perhaps too subjective and too closed, too often contingent on habit, familiarity and repetition and eventually run out of steam if regularly and repeatedly employed. In terms of order, stylistic canons eventually lose their validity, too. In classical architecture, perfect proportions were key criteria for beauty. The golden section, the golden ratio or the golden angle are well known, but hardly in use today (did you genuinely remember that the first is the number 1.6180339887, and the latter measures 137.5 degrees?); symmetry, rhythm and proportions are rarely discussed in a contemporary architectural context.
Without any valid top-down binary good-bad valuation principles, what we are left with is total insecurity, but therefore with the possibility to be creative. As Italian photographer Oliviero Toscani (2011, YouTube) states:

“Creativity is the consequence of a cultural action. That’s all! One does something, and people comment the result, “well, it’s creative”. Because it is new, because it was done with the courage to do things, to experiment on a new path. […] Creativity is based on, is the result of, something done with total insecurity! A real creative is total insecure of the result.”

As an educator, I ought to assume the responsibility to convey the innate and fundamental capacities of a designer to create now and into the future. Design-research is definitively related to premonition, but is truly motivated by individual observations, decisions and insecurities. De-sign assumes the Latin signum [sign] (Flusser, 1999 and Hill, 2006 pp. 33-39). We could mention the synonyms “project” [from prōicere: to throw forward], and the similar mind-set expressed in the German word Entwurf, rooted in the verb werfen [to throw]. As Coop Himmeb(l)au explains: “We break up the word ‘Entwurf’ [design] into the syllable ‘ent’ and the word ‘wurf’. Ent-wurf [de-sign]. The prefix ent as in ent-äußern, to renounce, or ent-flammen, to stir up. Wurf like werfen, to throw” (Kandeler-Fritsch, M. and Kramer, T. eds. 2005, pp. 20-21).

**BOTTOM-UP PEDAGOGICS**

A child trying to make a kite fly; a boxing trainer shouting encouragement to his pugilist from outside the ring; English teacher John Kipling (played by Robin Williams) inspiring his students standing on a desk to discover their love for poetry and seize the day – these are on the other hand examples of [again literal] bottom-up scenarios for facilitating someone, or something, to progress, to grow, to overcome a difficulty, to fight fear, to be curious. I mention the kite analogy as it promotes a system of interaction and dependency based on paramount criteria for contemporary educational models: dynamism and openness. The kite needs the right environmental conditions – i.e. wind, open fields – and an agile controller to fly. The boxing trainer on the other hand may signify what I consider an up-to-date approach to education, based on coaching rather than teaching. The scene from the 1989 drama film Dead Poets Society is inspirational to me, too.
In one of the most memorable scenes, English teacher John Keating solicits his class to open their books by Dr. J. Evans Pritchard Ph.D., a fictional character (Arcadio’s Weblog, 2009) on page twenty-one of the Introduction, and asks one of the pupils to read aloud the opening paragraph of the preface entitled Understanding Poetry:

“To fully understand poetry, we must first be fluent with its meter, rhyme and figures of speech. Then ask two questions: One, how artfully has the objective of the poem been rendered, and two, how important is that objective. Question one rates the poem’s perfection, question two rates its importance. And once these questions have been answered, determining the poem’s greatness becomes a relatively simple matter.”

If the poem’s score for perfection is plotted on the horizontal of a graph and its importance is plotted on the vertical, then calculating the total area of the poem yields the measure of its greatness.

A sonnet by Byron might score high on the vertical but only average on the horizontal. A Shakespearean sonnet, on the other hand, would score high both horizontally and vertically, yielding a massive total area, thereby revealing the poem to be truly great. As you proceed through the poetry in this book, practice this rating method. As your ability to evaluate poems in this matter grows, so will – so will your enjoyment and understanding of poetry.”

To which Keating, having drawn the graph onto the blackboard, replies: “Excrement! That’s what I think of Mr. J. Evans Pritchard! We’re not laying pipe! We’re talking about poetry. How can you describe poetry like American Bandstand” (American Bandstand, 2016)? Eventually, he requests the students to rip out the offending pages, encouraging them by the words: “Armies of academics going forward measuring poetry, no! We will not have that here. No more Mr. J. Evans Pritchard. Now in my class you will learn to think for yourselves again. You will learn to savor words and language.” What follows is the scene where he asks his students to step onto his desk to gain a different viewpoint of the class in order to open their mind. In my opinion, this passage from the movie epitomizes exactly that bottom-up and poetic understanding of teaching architecture that I am advocating.

Since we have put aside top-down criteria such as mind-independent parameters (with intensive and extensive attributes), user-centric properties (reactions and emotions), processes and stylistics order/s, we may now draw our attention to potential bottom-up alternatives. For example, capacities (open-ended interactions and interrelations with other material bodies), and tendencies (the possibility of variation, adaptability and change). Manuel DeLanda (2009, p. 12) suggests that capacities “are different from properties in that capacities are always relational.” Plus, capacities are more important than properties, given “that the number of things that may be combined with and interacted with is potentially open-ended”, unlike properties, which are finite in number and always given. Properties, on the other hand, “despite the fact that they are given and that they can be listed finitely, are also subject to what might be called tendencies. The tendency of material entities at certain critical points of a condition allows a change from one set of properties to another.” Such conditions of variability, openness and changeability are also inherent to effects, affects, haecceities and phenomena. Effects are caused by agencies and are, in Jeffrey Kipnis’ (‘The Cunning of Cosmetics’, 1997) words, more “visceral than intellectual, more atmospheric than aesthetic” impressions. Affects on the other hand refer to symptoms, to emotional changes. A haecceity, on the other hand, is a term “from medieval philosophy first coined by Duns Scotus which denotes the discrete qualities,
properties or characteristics of a thing which make it a particular thing” (‘Haecceity’, 2016). And which makes a student a particular student. Phenomena may also appear in this list as such occurrences, experiences, neither purely object-related characteristics, nor virtual potentialities are embedded within a feedback system of events and observations, of language and hence of communication.

With such bottom-up criteria it follows that a main characteristic of design engagement must be variability - and therefore I advocate openness, approximation, dynamism and hybridity as being appropriate responses and strategies towards educating architects. Coaching (not teaching) a student is a dianoetic process that proceeds by reasoning, argumentation and contemplation (by research). It requires reciprocal communication, two-way debate and cooperative dialogue.

**POETICS OF PEDAGOGICS**

Arguably, such modus operandi of research-led education can only happen and thrive on an open and "multivalue” platform (call it a unit, a studio, a lab, a cluster, an institute, a centre, a school or a faculty) and not at a similarly conservative institution, such as the Welton Academy in Vermont in 1959 where the abovementioned movie is set (poor Mr. Keating got fired, after all). In an open bottom-up pedagogic domain exchange and growth are nurtured. Everybody is asked to partake in researching and challenging the
risks, the unknowns and all indeterminacies of the past, the present and the near future. As Umberto Eco (1989) writes:

“Multivalue logics [...] are quite capable of incorporating indeterminacy as a valid stepping-stone in the cognitive process. In this general intellectual atmosphere, the [...] open work is peculiarly relevant: it posits the work of art stripped of necessary and foreseeable conclusions [...].”

When he writes “the work of art”, we may read: the work of architecture, or the work of education. Research-based architectural education must promote such open working conditions: architecture is an “anexact” discipline (Lynn, 1998, p. 41). Consequently, students should be allowed to define their own projected trajectories “stripped of necessary and foreseeable conclusions”. Whilst tutors should not follow established and partly mummified academic models of indoctrination and should not fear to foster curiosity in their students. This approach is experimental but risky. Thus states James Cameron [‘Before Avatar...a Curious Boy’, 2010], the American movie director:

“What are the lessons learned. Number one: Curiosity. It’s the most powerful thing you own. [Number 2:] Imagination is a force that can actually manifest a reality. [...] Don’t put limitations on yourself. Other people will do that for you. [...] Take risks. NASA has this phrase that they like: “failure is not an option”. But failure must be an option in art and in exploration, because it’s a leap of faith. And no important endeavor that required innovation was done without risk. You have to be willing to take those risks. [...] In whatever you’re doing, failure is an option, but fear is not.”

Thankfully fear is not an option, because an experiment is not only risky, but by default dangerous. Marcos Novak (2002) explains that there is a sense of danger in the meaning of the word “experiment”: the term derives from the Latin ex-periri [to test, to try], and periri from periculum, hence carrying the meaning of both attempt and danger. On the other hand, we could recount the term periculum itself to the Greek πεῖραν [peiran], meaning “that which is finite and can be experienced”. Experimental and experiential therefore lay closely together. Thus, individual, personal learning experiences are not a priori incompatible with collaborative, experimental scenarios.

Ergo, I would like to put forth poetics as a way to describe the making of an architect – an educational model that promotes a student’s individuality and nurtures her artistic and linguistic multi-voiced freedom of expression for differential interpretations of design intelligence. I am convinced that the concept of poetics and exuberance, which I have explored elsewhere (Colletti, 2013), stands in an intimate rapport to education. As Jan Turnovsky, I understand “‘excess’ as art, joy, imagination”, which are essential and yet ever so elusive qualities in many academic environments. I have already declared that, to me, design intelligence, architectural quality, and spatial intuition are not directly measurable, and hence not straightforwardly teachable. But I would claim that they can be researched on a platform of collaborative intelligence, network learning and distributed problem-solving.

Does this entail that poetics consequently present no “didactic character” whatsoever? I should emphasize that poetics is not used as synonymous to poetry. Etymologically, poetics stems from the Greek term ποιεῖν [poiein – to make]. If poetry is the form of literary art, “in which language is used for its aesthetic and evocative qualities in addition to, or in lieu of, its apparent meaning” [‘Poetry’, 2016], poetics is related to making, production.
This rapport is profound, as it is described in classical terms by Aristotle in his Metaphysics as the act of production following the thinking, noesis, as well as further strengthened by Plato to knowledge and by Aristotle to reason. In addition, poetics should foremost be linked to strategy. Turnovsky (2009, pp. 43-51) reminds us that, to Eco, poetics is similarly understood as “the form and structural plan of a work”, and “the artist’s operational programme”. He reinforces this by including the related concepts of “work-plan” and “work-analysis” to its meaning. What this elucidates is, that the goal of poetics is “to provide a means to infer, from how a work is made, the way in which the work wanted to be made”. He writes:

“The rational nature of the process of work-analysis itself, combined with the assumption that rational (intentional) elements exist within the object of analysis, lends the classical notion of poetics a constructive-logical aspect, which in turn allows it to be projected onto architecture in an almost exemplary fashion.”

I am aware that poetics as pedagogic strategy for research-led education may come across as too idealised, too intuitive (rooted in the Latin intueri [meaning look at, consider, perceive directly without reasoning]), or even too romantic. Indeed, strong eighteenth century romantic nuances, such as “idyllic” or “picturesque” are attached to the term poetics. Yet as Turnovsky states, “even in the emotionally charged Romantic period, the term poetics did not lose its association with reason”. If Novalis formulated: “poetry = art that stirs the emotions”, he also stated that poetry evoked “not only ‘moods’ and ‘visions’ but also, perhaps, ‘mental dances, etc’”; and thus the emotions “referred to by Novalis are not part of the specifically sensual faculties (sensitivity, feelings, urges), but fall under the rubric of the mind (thought, emotion, will).” This sustains my claim that poetics as strategy is a process that can be discussed, communicated and evaluated as pedagogic process for providing a framework for research-led education in the 21st century.

REFERENCES


Space & play time - the value of the speculative act in architectural design (education)

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INTRODUCTION

Across humanities and social sciences, there has in recent years, been a renewed interest in acts of speculation and their benefits to research and problem solving (‘Speculative Realism’ workshop at Goldsmiths College, London, in 2007, ‘Speculative Realism and Speculative Materialism’ conference at the UWE, Bristol April 2009, ‘Speculative Art Histories’ symposium, Witte de With Centre for Contemporary Art, Rotterdam, May 2013, ‘The Art of Speculation’ joint symposium, Berlin, November 2014 and The ‘Speculative Tate’ series of Talks and Lectures, at Tate Britain, London, October 2014 – May 2015). Speculation at one time was considered one of the highest forms of thought. This paper seeks to promote the act of speculative drawing as an integral part of a design process and supports this by discussing and evidencing the work of studio Unit 4, at the Department of Architecture, the University of Nottingham. This undergraduate studio, has for many years been interested in exploring and developing creative methodologies in architectural design education, that broaden the conceptual range by which architecture is produced. This is not so much about having an idea that conceptually challenges or provokes, or indeed about the finished object that may challenge and provoke, it is the process of the speculative acts in drawing that are the focus of attention; producing drawings that become territories and landscapes for thinking and speculation. This speculative approach over many years has encouraged, fostered and often created unique architectural outcomes that are unexpected and very personal. Underscoring the work lie the fundamental principles of drawing and thinking, questioning and reflecting; principles that enhance a student’s capacity for creative problem solving in an open and exploratory way.

THE SPECULATIVE WHAT?

So what do we mean by a speculative act and in particular the speculative drawing? What might inventive speculative practices look like in the design studio? These are some of the questions that this paper will consider.

Fundamentally this approach demands an ‘exploratory form of engagement’, as the Unit of Play at Goldsmiths (The Unit of Play, Department of Sociology, Goldsmiths, the University of London) might
put it, but instead of the ‘development of experimental, interdisciplinary and inventive modes of thinking and inquiry in the social sciences’, the application here is to the pedagogy of the design process and the production of architecture. Instead of, or as well as, putting ‘ideas into play’, it is about putting play into ideas.

This paper is therefore about the performative side of speculation and does not attempt to consider its theoretical situation. However, it does support the reconceptualising of problems and the seeking of more imaginative propositions. The processes being discussed also require the continual asking of questions, particularly the ‘what if’ question? These processes demand risk taking and a belief and commitment to being curious and inventive. The risk here is being prepared to take a leap into the unknown. The speculative act engages students of architecture, specifically with the notion of enquiry through what one might call an ‘improvised thinking drawing’. In this way, and above all, it is a process designed to explore and broaden an approach to design and to find different and particular ways of doing things. Students work at this interface between the idea and the drawing; a position of great liminality and potential; a place where things become interesting.

The speculative act stems initially from the imagination and then demands critical reflections as the process continues. The act is made without dogma, prejudice or preconception. It is a stepping off point into an unknown place. Through this process of speculating by drawing, a subject is opened up interrogated and then released. These drawings are about study and research not graphic illustration. We are trying
to study and speculate within the drawing. As a consequence, the work is fresher and more engaging through its incompleteness and the ability to read into it many things (speculation). The speculative nature, the content, the process of study through drawing and the narrative, these are where ideas are worked out, not represented.

Peter Zumthor in his first lecture delivered in English at the Southern California Institute of Architecture, (November 1998 http://sma.sciarc.edu/video/peter-zumthor-2/) spoke about ‘preliminary promises’ in drawings and that he liked drawings that “reach out to the reality of the object”, referring to “permeable spots which allow for our imagination to enter and our curiosity about the reality to flare up.”

The speculative drawing is done to establish possibilities as well as priorities and to find an architectural vocabulary; drawings that translate thoughts, research and feelings. Sometimes conjectures are uncertain and sometimes assured. Although most architectural drawings are done to have an impact on the intended observer or to provide specific pieces of information, this is not so important here. These drawings attempt to capture the spirit and essence of the work; “the stuff of angels” as Ted Cullinan once observed (Cullinan, 2006).

The speculative drawing encourages and allows freedom to explore and express a thought or an idea. The speculative drawing seeks to find an authenticity and essentiality to an architecture project. It seeks to release the full architectural potential and meaning and to capture the mood and the moment.

It is vital that these drawings remain in the realm of the duality between reality and imagination. They set particular and peculiar touchstones and hold great richness and a sense of potency from which architectural propositions follow and against which later designs can be constantly checked. They are reference pieces for studies that follow.

THE SPECULATIVE WHY?

The approach of speculation by drawing is intended here to assist broadening the conceptual range by which architecture is produced. Within the praxis of architectural design, finding space for speculative acts is difficult and questionable. These processes
require more time and are demanding. However, students studying architecture have a privileged position and should be encouraged to use it. Merritt Bucholz, speaking at the Utopian Studies Symposium in 2013 (Professor Merrit Bucholz at the University of Limerick) described the studio space as “... a space of doubt. This is not a space of answers; this is a space of questions. This is a space of experimentation. This is a laboratory, but above all it is a space of doubt.”

In an increasingly challenging architectural educational environment of constraints imposed by universities, ARB/RIBA prescription of validation criteria and EU Directives, it is important to still find space for diverse approaches to solving design problems. In the practice and learning of how to design, speculative approaches that push at the edges or through these constraints are of use. Linked to this is the need for students coming into university education, and in particular to study a programme such as architecture, to free up and value new ways of thinking.

The nature of a speculative method, in what is an increasingly dynamic and complex world of architectural design and practice, seems not only appropriate but potentially rewarding in a way that the traditional iterative singular approach cannot. It is inherently flexible as an approach and adaptive. Can we persuade that this is a ‘productive mode’ of thinking and this method of speculation when used as an integral part of the design process has the ability to create particular and special pieces of architecture?

One of the most important aspects of architectural education is the instilling in students of an ability to think and reflect critically about the work in hand. Encouraging and fostering an enquiring, thinking and critical design methodology must be paramount. This is at the heart of working speculatively. As we will see it is not only about the need to play or explore creatively and freely but equally important is the need to reflect and question critically.

It could be argued that designing a building is in itself a speculative act or at least it should be. When a building becomes part of a catalogue of products and processes, it will inevitably have lost something. Could a speculative approach to design, alongside the traditional iterative singular approach, add significant value in an increasingly complex, fluid and dynamic practice environment?

We have found in practice, in the design studio, that it is not only the accomplished students who benefit from these processes. The students who are still finding their feet with designing architecture are often able to produce a piece whether drawn or made that has real quality about it. This will not be a building and so the student’s inherent weakness in their ability to progress with a normal design process is not exposed at this key stage. However once this piece has been done it ‘traps’ the clues of a successful outcome and becomes the touchstone against which the future design can be checked and measured. Does the design, as it progresses, retain the key characteristics of the touchstone drawing? Does it achieve the things that the work so eloquently spoke about? Students can measure how their work is progressing. This is an understandable process. For the more able student there is a sense of a different challenge and an extending of skills by a broadening of their thinking and approach.
that in turn produces a richer outcome. These are challenges that we believe are worthwhile. The drawback for the students is that this approach takes additional time in an already demanding schedule; a schedule that can be rigid in its application. It therefore requires a sense of confidence and trust shared mutually between student and tutor in the process. From left and right, the students, who will be exploring and speculating, will also have technical demands made upon them and will need to justify their strategies and functional rigour, perhaps at a stage when they will be more exposed and uncertain. It is to their credit that the nature and quality of the work, having navigated through such demands, has been acknowledged by Departmental awards and by inclusion in exhibitions at the RIBA and the Royal Academy.

THE SPECULATIVE HOW?

The speculative act promotes the idea of enquiry and reflection. In Unit 4 this speculative questioning of ‘what if?’ and then the critical reflection, is done through drawing. The speculative drawing is a free ‘abstract’ drawing through which a thought or an idea is explored and expressed. So how is this done and what does this look like in practice?

The speed of the initial drawing is important. The time taken could be as short as 7 or 10 minutes or it could be done in a day’s workshop. The media used for the work is also important in that it should promote the freer or broader approach. Charcoal, pastels and broad brushes are useful as is papier collé.

By fostering and promoting a sense of play and encouraging working quickly, we
try to remove inhibitions and generate an intuitive, subconscious initial response. Preconceptions are discouraged and avoided. Students talk about a ‘gut instinct’ or the need to ‘get it down’ on paper or of ‘letting the hand go’. These responses are setting out starting points that search for the essence of the project. It is important that the drawings establish an ambiguity. We might refer to these as abstract drawings.

Clearly the first drawing can be made in response to the initial briefing. This can be followed by a response to a site or other key influences on the project at this early stage. These responses could be combined in one drawing. These drawings act as stepping stones into a project. At key stages through the design project other speculative drawings are encouraged. These are done to unlock a solution to a problem or to respond to an important more detailed component of the work.

The notion of play is important. Play suggests a creative freedom, free to play, to open up and broaden the approach. Play relieves the tension or straightjacket of the need to produce. This in turn breeds a confidence that can be carried through into the design process. The approach at this stage is not precious and therefore, working alongside each other, students feel comfortable in discussing their work and what they are trying to achieve. In turn, this confidence is taken forward when more specific, detailed, perhaps more difficult conversations are required, concerned with the nature of the architecture. These characteristics breed confidence in the student and their work. It becomes a personal thing and therefore also an emotional thing. With this attachment comes an ownership.

It is always good to jump in and play and to work quickly, but if this process appears too daunting, students can be led through a series of preliminary works that may lead on to larger drawn pieces. This process would include postcard-size drawings acting as cartoons, in the traditional sense, to prepare and guide the larger drawings. The larger drawings are the main setting of the speculation. One might understand this as a speculative method of working through play and time.
and the freedom that it generates. As important is the next stage of stepping back from the work before returning and questioning it.

Perhaps of interest here, is that in spite of the student being the author of the piece, its technique and its content, it is still possible and important for the student to question it by always asking what if? This is where speculation continues. What if I read that part of the drawing in a different way? What if I read the drawing as a section and not a plan? What if I move the ground position from here to here? What if the scale moves from 1:50 to 1:500? What lies within the blackness of the shadow? This ability to question a work in this way by its author brings a new dimension to the process and a real sense of speculation. It constantly asks the student to question everything. The drawings now become ‘questioning drawings’.

Discussions open up into unexpected areas that are not foreseen. Other areas of discussion to do with composition, balance and aesthetic judgement move to the front from the off, and an importance is placed on these criteria. Slowness is now useful with an attention to the detail and consideration of the results; what works and what doesn’t? This is about judgement of the components and relationships and in the end composition; what is useful and what is not. The priorities of spatiality, light, dark and shade, rhythm and pattern can be useful points of focus. Other important references can be brought into these drawings, blocks or planes of colour that could be identified as forming the space within the view. One could then look for rhythms and structures within the composition. Students will also look at the pieces to see where the eyes go
or to find the noise of the drawing before filtering out its content.

As a further example, in Bob Chang’s drawing (figure 6.), we are immediately invited to conjecture on what is happening. There are clear juxtapositions of scale. We are uncertain as to whether parts are sectional or shown on plan. There are components that could be structural, others that may be beautiful objects or places of enclosure. Overall there is a certain consistency and quality in the drawing and its vocabulary; no mean starting point for any building.

It is comparable with the task of interpreting a client’s brief, except that in this case we are dealing with a search that is not immediately for the plan or section of the building on the site but for a potential that the building might have. The drawings are therefore loose and speculative in nature. The drawing in this way is above all a thinking process designed to explore and to find a very particular way of doing things. If one thinks too hard about where to put a line there is nowhere to go with it or to play, or alternatively if one thinks too hard before committing to paper then a number of possible options or scenarios may be discounted without ever exposing these to play and speculation. Thrown into the mix are exercises in responding to music, situation and brief. Improvisation in music and to a musical piece enhances the experimentation and play-feel as well as demanding a response. The speculative how is practised. The use of the monoprint technique in printing, with its structured unpredictability, is both discussed and tried. Here the understanding of the ‘controlled chance’ is acknowledged and embraced.

Of specific importance is the extent to which speculation is used, and the ability to keep this process open for as long as possible. The drawing becomes a touchstone piece, to be referred to on a regular basis, as the project develops.

Does the project still contain the essence and character of the speculative drawing? What has been lost and why? Why can’t I get the quality of that drawing into the project? These are critical reminders and references. This is more work, difficult work and translating these ‘what if’ drawings into an architectural proposition is also not easy. It demands commitment, belief and a confidence that there is something there worth looking and working for. Perec, in particular, teaches us that if we are not seeing anything interesting then we are not looking hard enough (Perec, 1975). The architectural project becomes much more of an emotional experience.

These processes are challenging and demanding, and require additional time outside of, or in parallel to the iterative analytical process. The translation of this information into drawings that have architectural characteristics is equally challenging.

It is clear from discussions with students that there is a strong feeling that following a more straightforward design approach, for many, sets up a series of hurdles or even barriers that have to be negotiated. It is often possible to get stuck at these positions. With a freer approach from the outset the route does not feel full of such obstacles and even if one presents itself, because of the broader approach that has been taken, it feels easier to find a way to deal with it.
This process fosters a greater sense of ownership over the work. Each student will make the drawing in their own way using their own media. There is a feeling that the outcomes not only of the speculative pieces, but also of the finished building projects contain a sense of the student’s personality. Thus, the outcome can be said to be more personal and particular.

Students are not replacing any recognisable sequential design process, nor are they replacing fact with fiction; their projects still have to work and be buildable, and these studies are done alongside a sequential process, not instead of one. However, the uniqueness and personal claiming of their projects by individual students is impressive.

Gaston Bachelard in Poetics of Space states:

“Thus we cover the universe with drawings we have lived. These drawings need not be exact. They need only to be tonalized on the mode of our inner space. But what a book would have to be written to decide all these problems! Space calls for action, and before action, the imagination is at work. It mows and ploughs. We should have to speak of the benefits of all these imaginary actions.” (Bachelard, 1957)

And so what lessons for architects or students of architecture? We learn that if we do take an approach that demands constant observation and study through drawing it can be useful. With these tools, architectural design, when successful, can have a range and breadth to it that is not glibly and blindly reproduced without thought and without meaning. That working quickly to avoid preconceptions and
dogma is helpful. With students there is an acknowledgement that these processes breed a confidence not only in their skills but also in their readiness and their ability to engage with a discussion of their work. The processes enhance the creative acts in architectural design including focusing on composition and aesthetic judgements. And perhaps as important as any, students take ownership of their work and believe that there is something of their personality in the finished projects.

Finally, the Unit is interested in how can we enhance what we are already doing? What can be learnt from other disciplines where speculative work is being done? How can we apply the theoretical positions behind speculation within the unit? We are interested in exploring at which other points in the design process or indeed the practice of architecture, can speculation be applied and be helpful? Are there other ways of speculating that might also be worthwhile? Perhaps, it is after all, an aid to producing buildings that might in some way mean more, have greater relevance and even have the ability to move us.

REFERENCES

Online Source Material:
Bucholz, M. (2013) https://www.youtube.com/watch?v=kw1pNOwML08

With thanks also to Unit 4 students: Alice Chadwick, Arianne Dermawan, Mark Freeman, Jenny Hall, Rachel Li, Max Mackay and Jessica St Claire for sharing their views with me.
Fieldwork

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“Instead of causing us to remember the past like old monuments, the new monuments seem to cause us to forget the future. Instead of being made of natural material, such as marble, granite, or other kinds of rock, the new monuments are made of artificial materials, plastic, chrome and electric light. They are not built for the ages, but rather against the ages.” (Smithson, 1979).

The Anthropocene nature subjugated, relocated to the zoomorphic juncture of pure metaphor - a romanticised fictional image of self. At the intersection of postmodernity, everything that was once stable appears to have become uncertain. The powerful interplay between the forces of nature, and technology, against those of culture and economics – construct strange distorted picturesque futures - affected foreground, mid-ground and background. This shift of mankind from passive third-person observer of planetary systems and events, to that of central protagonist and principal architect of planetary change, underpins the growing argument that we have unwittingly precipitated and crossed an epoch boundary into a new geological period.

Air-Plain Continuous Construction No 01: Above the man-made Playa of the test site, in a state of total arousal. Air-Plain, a vast labyrinthine structure, a non-monument, continually evolving autonomous complex. A moderate Utopia - plugged, clipped, jacked, hacked, tuned-up, mashed-up, a wired-in - total consumption machine. Within the expansive field – an illusory environment of intricate data systems, landscapes of unknown authorship and shared pathways. Buffer Zones – construct boundary layers to the peripheral of the visible. An understanding of the invisible is rendered through an examination of its inherent invisibility. Within, anthropologists wage ideological battles between objectivity and subjectivity, culture and text - systems of classification and disorder.

Fieldwork: This paper will reflect on the tools, practices and function of Fieldwork, defined as a primary analytical tool, central to architectural design studio culture. Presented as the practice of active, creative curiosity, a catalytic mechanism deployed to challenge preconceived readings and prejudices, to decode and reflect upon the familiar and unfamiliar alike. Within this expanded field, survey sites to sites of display, orthodox dialectic instruments of enquiry will be finely balanced against those of inexplicable paradox.

We will consider the observational manuals of Karl Baedeker, handbooks for travellers – to the romantic architectural wanderings of Mornings in Florence.

Figure 1 Air-Plain Continuous Construction No 01 – By Simon Herron, Nick Szczepaniak with Susanne Isa and Jörg Majer [E.R.I.C] 2014
(Ruskin, 1881) or Learning from Las Vegas, or Form Analysis as Design Research (Venturi, Brown and Izenour, 1972). What tactics, what methodologies can be imagined for the near future.

**The Anatomy of Melancholy**, “what it is, with all the kinds, causes, symptoms, prognostics, and several cures of it. In three partitions; with their several sections, members, subsections, philosophically, medicinally, historically, opened and cut up. By Democritus Junior [Robert Burton- author] with satirical preface conducing to the following discourse” (Burton, 1621). An analogue compendium and guide book, a 17th Century universal model of everything. Compiled to account for and explain all human emotion and thought to date. No beginning or true end, a deliriously complex interwoven structure. Witches and magicians, the geography of America, digestion, the passions, drink, kissing, jealousy, or scholarship.

**Fortresses of Solitude**: Unorthodox landscapes of contemporary curatorialism – The New Wunderkamme. A taxonomy of meticulous facts, footnotes, exhibit cards, carefully catalogued listings, sources, and citations, provenance recorded, all supported by the reassuringly confident tone of the absent narrator. A delirious journey confronting complex strands of interwoven narrative and inexplicable facts; finally balanced on the edge of reason and bathed in doubt. Historical Arcane and Natural Curiosa originating in the private collections of 16th and 17th Century Europe, to the Museum of Jurassic Technology, Los Angeles; the expanding network of presidential libraries, powerful vitrines of state, immortalising past leaders into the new deity.

**The Whole Earth Catalogue [Access to Tools]**: Produced by Stuart Brand in California, in Autumn 1968, following the Summer of Love. Seen by many as the forerunner to the Google search engine. An analogue system produced with polaroids, hand typed, cut-up text on cheap paper. This was seen as a contemporary open source evaluation and access mechanism and user manual to the counter-culture of the 1960’s. Like Burton’s Anatomy of Melancholy, both present contemporary idealised worldviews, functioning as compendiums of thought and practice. Both attempt reconciliation of complex whole systems – or gestalt. From land use, communication, community, through ideas of nomadism and learning.

**The Other Theory of Physics**: A unified theory of mass, space and time, developed by the amateur physicist and trailer park proprietor Jim Carter. In an age of on-demand content, encyclopaedic inventories, and self-authorship, where everyone their own curator, in the shadow of Marshal McLuhan’s Gutenberg Galaxy, an endless library of Babel, to the internet of things. In this new landscape where printed content remains largely unread – pointlessly aestheticized and stored. Technologies of agency evolve as seamless anthropomorphic haptic extensions of self – tirelessly, yet relentlessly exploring the world on our behalf. In the Anthropocene, sites are physical and immaterial, both are subjugated and experienced by our digital selves – outsourced and endlessly shared – to online content of Facebook and the cloud.

**Camera House**: An assemblage of a domestic environment with inhabitants and programme. The house as co-protagonist - registers mundane and imperceptible events in the lives of its inhabitants on its photosensitive surfaces - recombining and juxtaposing programmes. Various mechanisms constitute house - kettle switch, spilled coffee, elevated humidity - all involuntary triggers for specialised shutter-release. The kettle switch floods the dining room – illuminated for one thousandth of a second. The spilled coffee drains
through the floorboards starting an exposure that might last for ten years or more. The house is wired and chemically active - it is vivid and visceral - a collaborative involuntary proto-nervous system.

Gas Tank City: An anonymous architecture of transient structures – rigs, trailers, tanks, endlessly traversing the permanent infrastructure of the highway logistics system. 43,000 miles of hardtop - a single unifying militaristic entity of deep paranoia. Gleaming machines, constructed from mass produced industrial components - complex assemblies of hardware rendered visible with azure blue light. An architecture captured in momentary stasis - viewer unseen. Each image, the consequence of an elaborate transformative process. Light captured on 35mm film, carefully transposed to a solid paper ground, Derwent colour pencils, gradually build intense layers of super saturated colour. The resultant image a radiant melodrama of Californian light.

“...That stronghold which was to be my secret sanctum...My hideaway... The one place, perhaps, in the whole universe, where I can come to study...To contemplate... Or to simply relax... To shut out the whole world, and be alone...As every man needs to be at least once in a while... I remember how, years ago I first discovered this desolate spot - and returned later to turn that desolation to my advantage.”

(Superman introducing his incredible Fortress of Solitude – All new collector’s edition. DC Comics Inc., Summer 1981, DC Series Vol.5 No. 6).

REFERENCES

Robert Burton, Priest and Scholar, The Anatomy of Melancholy, First published 1621, obsessively rewritten, revised and expanded in five subsequent editions.


Robert Venturi, Denise Scott Brown and Steven Izenour, Learning from Las Vegas, or Form Analysis as Design Research, First published 1972, original fieldwork undertaken with Yale Architecture Students in the Fall semester, 1968.
One of the main drivers to online teaching and learning in HE has been the strategic influence of HEFCE to embed a greater use of technology for enhancing learning, teaching and assessment (HEFCE, 2005/12) over the next 10 years. The term e-learning is a term used to describe the vast technological developments and approaches. It “looks at how institutions can enhance learning, teaching and assessment using appropriate technology.” “Enhancing learning, teaching and assessment through the use of technology is one of a number of ways in which institutions can address their own strategic missions.” (webarchive.nationalarchives.gov.uk)

INTRODUCTION

Students at any level of their journey through architectural education can find themselves at a loss when attempting to document their personal design process. It can be hard enough to construct and maintain a solid concept and presentation of the final proposal but to meet the expectation of tracking and recording the design development process whilst successfully communicating the design thinking behind the project, can prove to be a daunting challenge, particularly for those students at the beginning of their education. Similarly, it can be difficult for educators to fully appreciate the detail involved in the design investigations that derive outside the studio yet provide a critical explanation of the “final” idea pinned up on the wall. Many untracked studies can be lost, models crushed and sketches abandoned; I was interested to know more about what I had been missing out on.

Introducing “blogs” into the delivery of architectural education at my previous institution in 2012 marked the start of a series of “happy accidents”; a number of positive outcomes, unanticipated and unexpected results that have brought about many new practices and collaborations. Consequently online tools have now become a grounded and well-integrated part of my studio teaching. Through the use of blogs I have been able to construct an instantaneous connection between the students’ personal design journey and the web, providing awareness for fast and diverse feedback, together with a way for me to assess the whole spectrum of the students’ design ideas — rather than simply the end products. Blogging has enabled changes to be made to how the programme can be marketed, enabled connections to be fostered both locally and globally for various project collaborations, opened up new opportunities for public critique and also uncovered evidence which provides encouragement for continuing to explore the use of social media in studio in future years.

Through use of examples and experiences collected over a period of 4 years, this paper will present and evaluate how I have used blogs, beginning with the journey that I embarked upon in 2012 with the intention of strengthening
reflection in architectural education, assisting student communication of projects both verbally and graphically, to integrate more collaboration in studio with other design courses and also to provide students with the ability to create a digital identity for themselves both at university and upon entering the world of work. Following this initial evaluation, an overview of the events that unfolded as a result of a move to a blogging community will be given to highlight further advantages of this practice. The paper will then lead on to describe how these original discoveries were explored more deeply, following a visit to the USA in December 2014 which triggered an opportunity to further integrate the use of blogging into the studio and to test this technology in a different context, a different country and with different students. The second half of this paper will thus describe the outcomes that came about by introducing blogs and social media to an existing studio at Marywood University, USA and the questions posed and answered via this study. A description of how these have helped strengthen an understanding of how this technology can enhance the studio experience for students will be presented. This study and collaborative pairing which is still in place, has enabled both myself and my co-author to continue to investigate the use of social media in studio and to test different speculations such as whether it would be possible to utilize blogs as an extension to the 1:1 tutorials already in place.

BLOGGING

Introduced on day one at first year level 1 as a tool for recording and communicating ideas, blogs are now frequently seen in the upper years of the programme together with alumni of the school, who are now moving forward into their careers after education. There has been no question as to how useful the blogs have or will be to the students who have embraced this technology fully, and in hindsight I often wonder why I did not explore the use of a similar design tool earlier. Although not compulsory, the induction week prescribes an engagement with blogging technology to introduce the students to recording their design development online. From this point, blogs remain as a key part of the students’ learning journey throughout the Level 4 programme. We discuss them in tutorials, students can present verbally with them as a structure for presentations, whilst also forming a good proportion of the discussions that happen outside of tutorials via email. The blogs, through their accessibility, have become a good format for suggestions and compliments from tutors, which has transformed the studio culture by enabling deeper discussions to take place in terms of the students’ design processes in between the formal timetabled sessions. As previously discussed, the current situation has not always been the case and “pre-blog”, in 2012, I was facing problems of poor attendance in feeder modules, a weaker engagement from international students due to severe language barriers and a general poor understanding by students of the value of contributing subjects such as architectural history and theory.

My first encounter with blogging technology was an attempt to highlight better connections to supporting topics and their relationship to the “design studio” module. Initially asking the students to “blog” their lecture notes, I intended to enable the content of these modules to become more accessible digitally as opposed to hand-written notes stashed in the back of a folder, and to enable the material to become “portable” so it could be discussed more easily. Together with using similar precedent studies, sites and other material, the aspiration was that the cohort would begin to realize that studio, although a key component of the architecture course, was not the only module of relevance to their training to become an architect. The outcome of using the blogs in this way evidenced a clear shift in attitudes by the students and to my complete surprise, the students not only began recording their work for history and theory lectures - but all work
- for all modules. Happy accident number one had occurred. One student commented “by having all my work in one place, I was able to see the relationship between my modules more easily”. Another said “I often look at other students’ blogs and learn from them. I feel if I load up my work to the blogs I know others will be looking at it. I feel it is important to keep it looking good.”

Blogs assist the students to collate their thoughts and work for the course with a holistic mind as opposed to a secular one. They extend the tradition of private critique occurring within the interior of the studio walls and put the student work into a larger context enabling self-reflection and a more rounded consideration of their course. These first steps in creating a blogging culture certainly had an impact on the students’ attitude and approach to displaying their work. An improved level of pride developed within the student for their work and their online display of themselves. A format that can be seen by friends, tutors, peers, family and the general public, the students began to recognize the importance of representing themselves online and through online communication and presentation, the group progressed further in self-evaluation and became critical of their own personal learning path.

During my first year of blogging I found myself faced with several advantages of the technology that I had not anticipated. A lack of confidence when presenting verbally, a poor ability to document development work and a nervousness when declaring sketch work in projects, first year students are a sensitive group to encounter. Making discoveries, learning new skills whilst at the same time attempting to establish who they are within the context of their school and their studio, their journey through architectural education can be a challenging time in more ways than one. Using the blogs as a tool to record and evidence each step of the design development process and therefore their learning journey, I wanted to help develop the students’ confidence by encouraging them to connect with what they produced, and reflect upon their improvements as they progress through the year. Often we encourage students to look ahead towards the cohorts of second, third year and even Masters level work. However, sometimes it can be more useful to appraise work gone by in previous projects and make comparisons to the work currently being produced. Learning for a first year student is fast-paced and to keep up, new skills in communication and representation must be acquired relatively quickly if they are to present their ideas successfully. Through the use of blogging, the students were able to “carry” around previous projects and work with them and have it to hand to call upon when necessary. A frequent practice in studio became about “reflection” and looking back at earlier projects in the critique of a current project, enabling tutors to highlight to the students the new skills that they have learned and improvements made. The benefit of the blogs is that the students can also do this themselves at any point. The blogs provide a fantastic test for the logic of one’s process, and provide tutors with the ability to view the “whole” student, not simply one project in moderation and marking. Blogs can therefore also be an encouraging tool for tutors to reflect upon student progress quickly and continuously. As opposed to waiting until the end of term/year portfolio review, one has complete access to all student projects and modules at any one time.

It was also clear that using blogs to help students when verbally presenting their work provided a structured, chronological and graphically pleasing record for the students to use as a prompt in design reviews. Computer screens or laptops were provided in the design reviews for students who chose to present from their blogs, and blog links were recorded to enable tutors to refer back to the development work for marking. This noticeable shift in studio culture meant that it became much more comfortable for those students
who struggled with confidence when speaking in front of an audience, for international students needing to overcome the language barrier and in general to assist all students in learning the skills necessary to present their work in an orderly, chronological format to better explain their project from concept to the final proposal. For the tutors, the blogs revealed the attempts to develop design ideas at various stages of the design process and for one to understand the learning path taken by the student, pushing beyond the limitations of a strict portfolio, the blogs have become a useful aid to better communicating with the student about where they can make improvements and which ideas (throughout the whole design process) would have been useful to work up further.

As an aid for storing ideas and saving work, the blogs have also become a favoured and reliable tool to refer back to should work become lost. Students commented, “as a tool for reducing printing costs the blogs are great! I can take photos of my models, save images of my precedent studies and scan my sketches all in one place without having to print them off for tutorials. This has saved me lots of money!”.

FOR FEEDBACK AND ENGAGEMENT

Being able to provide formative feedback on the blogs at any point in between project submissions, tutorials and timetabled contact time with students has enabled myself and the other tutors with the opportunity to provide interim guidance. This guidance would not have been possible before the blogs became integrated into the studio due to a lack of time and lack of studio space for additional tutorials. For beginning design students embarking on a new subject and new course is daunting and as a result this hesitancy to make design moves can hinder learning. Early intervention when a student begins to waver on their design decisions, lose confidence or even become disengaged has proven to be very helpful when attempting to maintain good retention. This type of feedback has been called “Advice for Action” (Whitelock, 2010). Solid data and student feedback collated over a period of 4 years at NTU has suggested solid evidence that blogs can be one way of aiding students during their first years of learning, reducing the fear and consequently improving progression. Maintaining a higher level of inner confidence with the students has also helped to improve attendance. One student commented “I like being able to send my work in development to my tutor. On my blog I can upload my sketches, thoughts and scribbles and my tutor can see it in context. Support between tutorials has helped me stay on track when I have been stuck. It helps me catch up”.

Not only does the drawing together of information into one place become beneficial from the point of view of feedback, but it also aids students to visualize their growth of knowledge, understanding, abilities, motives and demonstrations of learning in their design development, whilst at the same time enabling an easier transfer of information from and to contributing modules. This saves students time and as previously explained, encourages positive reflection. From the beginning of my blogging initiative, I started to notice a drop in students falling behind with their work or reaching the end of project review with nothing. Almost all of the time, some useful work can be found on the blogs to assist the student in presenting their work in a way which is useful to the critic.

Although I cannot finitely link an improvement in student attendance completely to the introduction of studio blogs, I can evidence that some students who missed sessions were able to be reintegrated into studio more quickly by tutors being able to communicate with them via the blogs when absent. Students missing studio sessions were able to communicate with me outside of the timetable, which meant I was able to assist them to catch up and feel more able to return to the programme following an absence.
TO LIST ADDITIONAL “HAPPY ACCIDENTS” THAT OCCURRED IN THE INITIAL YEARS WHEN INTRODUCING BLOG TECHNOLOGY INTO THE STUDIO:

1. Blogs provided students with the ability to capture their ideas in a range of different, non-standard formats, eg: video and photography, screen grabs of CAD in the process of construction, and store them digitally ready for review and presentation at any stage of the design process. See graphical examples as part of the appendix.

2. The blogs reduced time wasted for students when working independently on ideas away from the studio and made scheduled tutorial time more productive.

3. The blogs presented an online persona for the student further developing a confidence that some did not have in the studio and one that could then be nurtured by the tutor.

4. The blogs supported student learning through play when undertaking tasks, which sometimes can be very formal. Incorporating their reflections, thoughts and feelings about the project, the cohort began to engage in more active discourse with both their tutor and peers.

5. Blogs encouraged more peer learning and collaborative practice opening up studio projects to a wide range of possibilities for group work and sharing practice.

6. The blogs created a space for facilitating a more expansive reflective process and continuous review of previous projects, which once “live” can be made continuously accessible (as opposed to in sketchbooks tucked away at home), the blogs encouraged students to become more aware of their own learning and promote critical evaluation of individual progression.

7. Reduced the amount of work “lost”. Models were captured in process and sketches were recorded. The development process involved in their designs had been stored and became visible.

Reevaluating the use of blogs each year has seen the use of this technology grow and become more integrated not just in studio practice, but in other modules to help students learn how to reference essays correctly, for correct use of precedents and for creating a full academic portfolio to send to potential employers. In the past year I have also begun to use the blogs to communicate with new applicants to provide them with a snapshot to the course that they otherwise would not have had. Being able to tune into a “live feed” of the studio and other modules has provided potential students with the ability to really pose the question “is this course for me?”. A more honest and open representation of what learning architecture is about facilitates a better chance of the right student being placed on the right course. A better presentation of the course content has also been made to international students and those who cannot attend open days or applicant days. Using some of the student blogs, which provide an excellent representation of the modules within the programme at my school, has enabled me to communicate better not only the academic content of modules but the enthusiasm and activity that happens in the delivery. A flavour that you cannot attain through conventional marketing via a prospectus. I have used the student blogs to send to newly registered applicants to help them prepare for their arrival to the university and whilst this has put pressure on myself to have to reinvent projects each year, I feel this can only be a positive pressure to ensure my studio is consistently new and refreshing. Happy accidents that have come about from using the blogs in this way include prospective students that have attended applicant days emailing me their school
work via blogs they have been encouraged to create, a domino effect happening within my school with colleagues now taking up the use of blogs within their programmes having recognized the benefits, not to mention the many collaborations both locally and globally that have been made possible by the ease of sharing material online.

In addition to the potentials within studio discussed above, as referenced here we also began to consider how social media might also be used collaboratively apart from the tutor/student relationship. To continue the earlier discoveries, I wanted to look deeper into one or two of the benefits uncovered by previous research. Could the blog, or other social media outlets, be used as a beneficial critique tool on a larger scale? The process could expose students to perspectives outside of their own university or country, to link at a 1:1 level with willing educators and professionals in other places with no cost to the universities, and gives the individual critic more time to engage with the work.

Having previously begun using the Weebly model introduced by Victoria, the idea of using a proprietary Facebook group with selective membership was an area of exploration as well. This began through a sponsored design studio run in the summer of 2015 at Marywood University with the Dallas Texas based furniture company Groovystuff. Due to the nature of the studio and its relation to a design manufacturer, a more private setting was desired. Using the Facebook group with the studio instructor and company president as trusted administrators allowed for the invitation of select critics without the potential dissemination of design material to other manufacturers. The ‘security’ of the site resulted in candid, informal discussions and critique from all involved. The students posted their work, from inspiration and sketches to models and final product boards, on a weekly basis. This would garner feedback from the Groovystuff team in Texas as well as from myself. As a collaborative tool from afar, postings could be accessed at any time of day and commented on/replied to many times. In this way, each iteration or thought could be presented, documented, and developed in a timely fashion. The private nature of the group allowed for informal as well as formal critique and response from the students.

In the autumn of 2015 I chose to build on the experience from the summer and engage in a project with my second year design studio at Marywood University in order to explore other avenues of social media critique for comparison. The second year ‘Fall’ within our sequence is a shared studio between Architecture and Interior Architecture students and acts as a bridge between the abstract quality of first year and the more concrete reality of upper levels. This project involved an introduction to site conditions as well as basic programmatical issues along with continuing exploration of graphic communication. None of the students had been a part of the summer group, and so did not have preconceptions going into the process of using the blog as an online critique tool. The students were in the final stages of a half-term project, and we paired them with critics from Europe that we felt would work with the studio level and critique method. Critics came from academia as well as from the profession and were located throughout England with one coming from Austria. Being a new format for both the critic and student, we allowed for a certain amount of openness to the process to be able to assess the tendencies of all parties involved and gauge how to modify the methodology. The online presentation model requires and encourages the student to address their work in a different manner, without relying on being able to talk around an issue. The student needed to explain the details that they feel are important to a greater extent, to ensure that the point is seen rather than relying on it being discovered. Through this the students must consider how they best accomplish this through a balance of image and text.
The critics were given a cursory introduction to the project and were able to dictate how they delivered their critique, whether directly as commentary on the blogs or as separate documents, and were given a one week timeframe in which to respond to the blogs. While the prospect of a virtual 1:1 critique does allow for more focused time as well as more flexible time in which a critic can engage with material, rather than sitting in front of 20 students over a 5 hour period, it does allow for the possibility of time getting away. I found that the timeframe worked well for some while it, coupled with the process being open to interpretation for the initial trial, resulted in several of the critics responding at the one week point, or much later.

From the initial blog-based critique model we have been able to process information on the potentials and pitfalls of the process from both the side of the critic, Victoria, and of the faculty, Stephen. The students need to be urged to explore how best to communicate their ideas without interacting with an audience. The Marywood students have been working with the blog as a documentation tool for less than a year, and for many of these students it was their initial experience of the medium. With continued use of the format for documentation, the students will become more adept at communication without direct interaction and will be able to better represent themselves in critique. As the faculty involved, there is need to develop a rubric to alleviate the pressure on the invited critics. We found some critics were uncomfortable posting publicly and returned feedback via email whilst others typed feedback direct to the blogs.

The experiment posed further questions: What is the potential for social media-based critique, whether formal or informal, and will it replace the in-person dialogue between critic and presenter? The potential is limitless as a means of connecting students with peers, academics, and professionals outside of the scope of their surroundings. As far as replacing physical interaction, we say no; augment the experience, yes. The contact time we spend with our students is at such a level that they are prone to tune out at a certain saturation, this would be a point that another opinion (even if it is saying the exact same things) might be the one heard. In the society in which we live, often people strive for more ‘likes’ on a post from people that they do not know than for one positive comment from the person sitting next to them. Exposing the student to a new body of knowledge or way of working can only help to push them forward in their own methodology. In addition to this, we plan to further explore additional linkages that could be made beyond peer learning in studio or indeed the school or country, but also to investigate peer learning between students from various universities and to elevate the consciousness of social media to work towards a greater use. How can social media be used not only to show students what has been done, but to allow them to see what their peers are doing not just in the final outcome, but in the iterative steps of the process to allow for questioning each other to develop their personal language.

FURTHER DEVELOPMENT WORKING WITH BLOGS

Through undertaking these exercises we have uncovered a wide range of additional benefits from using blogs. The audience has heard a snapshot of just some of the discoveries and investigations we have been making.

We have since expanded my strategy to begin to address how the resource can be more widely used within my programme and further afield. Already members of different faculties at Birmingham City University have begun to see the benefits of blogs used in this way and have begun to introduce it to their own courses. This also includes the workshops and HR and I am keen to record the outcomes of all different routes the blogs may define.
Over the last two years in the UK, alongside Stephen working in the USA we have been making blogs accessible to new applicants in order to showcase the activities that are happening in studio to more accurately portray what the architecture course involves. This honesty and transparency for students is, we believe, critical in assisting them to make an informed choice in regard to their place of study. Incorporating the blogs into open day material, applicant days and other marketing material gives students a live “snapshot” of studio life. In my studio I have also witnessed students sharing their blogs with families and friends outside of the course, which has gone someway to bridging the gap between students and their circles at home. I have helped students build up their own digital CVs and become better prepared for selling their work prior to an interview. I have also expanded the use of blogs beyond Year 1 Undergraduate level to implement my e-learning strategy with a group in Year 2 in technology modules, at Masters level with dissertation students and in collaborative projects, which have involved architecture students working with Fashion design. Each one of these initiatives have been made possible through the use of blogs and social media. We look forward to exploring further possibilities with this initiative, and witnessing and being part of more “happy accidents” in the future.
Learning environments in design studio culture: exploring the student experience

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Central to any architecture course are the activities of the ‘design studio’. The term embraces a culture of formal and informal activities focussed on project-based learning. A design studio also includes the physical spaces of the studio and possibly other work and study spaces, bound together by a language and culture of expectations, practices and values.

The research discussed here was undertaken in a UK school of architecture with a typical studio arrangement; demarcated spaces for years or groups (ateliers, studios or units), in a larger open plan environment. Students negotiate within the group for the use of the shared workspace, which also operates as a teaching space.

Learning in design studio cultures has been theorized as a signature pedagogy emulating professional practice models, as a community of practice and as a form of problem-based learning (Shulman, 2005) (Love and Wenger, 1991, Wenger, 1998). These concepts are reflected in emerging models like the London School of Architecture (www.the-lsa.org/network), through dispensing with dedicated studio provision; aiming to relocate existing signature ‘pedagogy’ elements (the crit, the 1:1 tutorial), and relying on professional practice communities to nurture students’ learning. But what of existing architecture schools with their studios and workshops? What is the value of informal studio spaces as an umbrella setting for teaching and as a creative space for student learning? Given that the studio is a major investment for Higher Education Institutions, this research asks what role traditional environments like the studio have in supporting design studio culture beyond actual teaching sessions?

RESEARCH METHODS AND APPROACH


Five themes emerged from the analysis. The overwhelming focus of work was portfolio production, but was mediated, and often impeded by uncertainties of tools, equipment and other necessary things. Students articulated their involvement in studio culture through the terms of a notional community, with a social milieu that supported peripheral collaborative and social activities.
that surround formal teaching, with decisions about where to work being informed by identity and sense of place.

Here I shall be discussing the notional community the students formed in the context of community of practice models and, drawing on Bourdieu’s model of practice, considering informal use of studio spaces as a social dimension that enables students to develop their habitus.

A COMMUNITY OF PRACTICE?

Communities of practice theory challenges the idea that learning happens through cognitive mechanisms (as put forward by Schön). Lave and Wenger’s model has obvious resonances with the activities of the design studio, both as a result of the problem-based learning approach and the student centred organisation of spaces and facilities (Lave and Wenger, 1991, Hughes et al., 2013). Examining the student community’s network against the accepted characteristics of a community of practice as defined by Barab and Duffy (Barab and Duffy, 2012) indicated that it held cultural and historical heritage, shared meanings, goals and practices, but that these were not inherited from older community members’ experiences. Tutors were seen as having a responsibility in galvanising the students rather than ‘old timer’ members. Student A described a Friday after studio:

“…we’re probably going to go for a pint or something. The tutors as well. Like it’s nice because most of the times they’re trying to join us as well…because like the tutor is the one who tries to bring everybody together. It’s everybody’s connection is in the middle so it’s the tutor.” (Student A)

The degree of identification with the community varied. Student M, who worked at home, was clearly sensitive to his peripheral place:

“Yes, I think in general I feel part of it if that’s what you mean? I feel part of it and I think they perceive me as well as part of it. They don’t think, ‘Oh this is the guy that never comes’ or anything like that. No I don’t think they have that feeling.” (Student M)

This understanding was at odds with other views, and the experiences of Student A, an ardent studio participant who used multiple means to ensure her presence in the community:

“our whole life basically has to do with us coming in every day and or even if I don’t come in it’s like all the time I mean…we have like a group you know on WhatsApp we have a group conversation so we’re like texting between us…the studio people all the time like where are you what you’re doing…” (Student A)

The social development of community emerged from working together on similar tasks and on stressing cherished differences between themselves and other (non-architecture) students. This community’s boundaries were tightly drawn around studio culture, sustained through a symbolic dimension in the form of values, codes and common experiences (Cohen, 2013).

Students talked about a currency of ideas and thinking, blurring boundaries between themselves and the community. They were prepared to share knowledge, within limits. Student L described requests on Facebook from studio non-participators:
“They are generally the ones asking, yes. There seems to be often a lack of reciprocation. You know, you will provide photos for everyone and maps for everyone because you have done the work, which can sometimes be annoying. But you don’t want to come across as an asshole.” [Student L]

The characteristics of this community reflected many aspects of Cohen’s analysis: The students talked using a shared identity and repertoire of actions, and could describe their social boundaries (Cohen, 2013). This analysis concurs with Morton and Shreeve in so far as finding that a community of practice model was not reflected in the studio environment, and furthermore not outside it either, but did not conclude that this was the result of independently focussed practices (Morton, 2012, Shreeve, 2007). Students did not operate as isolated practitioners - even the most peripherally engaged students made efforts to keep up tenuous membership. Contrary to Lave and Wenger, students’ identities were not forged through community participation: students learned to belong, but did not behave as newcomers; they brought background experience and expectations, showed prior familiarity with design studio ways and were quick to develop their new identities, reflecting popular representations of design studio culture in the media (Frederick, 2007).

Bourdieu’s theory of practice has relevance through the way it relates individually acquired ways of working to social contexts, where habitus involves the externalisation through the social realm of previously internalised habits and practices. The research suggested that the community acted as a field, in which the student could develop their habitus, acquiring social capital (being contactable, being the centre of things, driving the social milieu) and cultural capital (practicing-knowledge). Students with greater experience were not seen as ‘old-timers’ by others, and were quite guarded about sharing their knowledge: they did not reflect community of practice roles in this sense. Their practicing knowledge and habitus offered ‘distinction’ that was not freely given away.

The research echoed Webster’s point that learning, in the form of making sense of disciplinary knowledge, was happening outside of formal teaching (Webster, 2008) and in a realm that included, but was not limited to, the studio spaces. The social milieu of the community was a space for reflection along the lines of talking through, making sense and ‘playing the field’ (Bourdieu and Nice, 1977).

BEING IN PLACE/OUT OF PLACE

Students worked in the studio and workshops, the library and at home, in their bedrooms, living rooms and kitchens. All were restrictive in some way or other, but did not appear to determine outright their working patterns. The students held in tension two often conflicting desires: to create an equipped space of creative potential free from practical and time constraints, and the need to work or simply ‘be’ in the presence of others. For example, although the studio was seen a messy workspace and suitable for modelling and constructing, students talked about setting up at home, in their living rooms and kitchens: They would either have a small home studio permanently set up, or temporarily convert shared or family spaces.

I have used the envelope terms of being ‘in place’ and ‘out of place’ to characterise the uncertainty of studio as a place of work and the importance of social milieu in shaping this. Students described setting up workspaces at home where they would feel ‘in place’ and ready to work, in a supportive environment and with the right things to hand. For the most part this involved temporary setups, for weekend and night-time to support work done in the studio:
“Previously I used to just work on the living room table, but then you get slightly distracted...You need to be set up properly...You need to have all of these things, just to make your life easier, to ease into the work.” (Student R)

“At home I don’t really do work on my laptop... I’m probably on my drawing board because I don’t bring my drawing board into the studio so I’m probably drawing at home or model making. I’ll just take over the living room, just have it all over the floor...” (Student S)

Student A described turning her shared living room into a plaster-modelling workshop: a time-unlimited space for back and forth working. Students used social media, like WhatsApp, to support being in place at home and working on their own:

“Then at home, if somebody was not doing okay, then we would just call up, talk about it...when it comes to not being able to figure out a particular thing that’s when the phone comes out.” (Student R)

For other students, the studio itself was the space where they felt more ‘in place’, with both social activities around sharing work in progress and mutual support, and material activities of getting on with work.

“I mean it is not so much about them seeing that you are doing the work because they see that anyway through your work, but it is more about staying there...and there are always people who ask for help, so that is reason we stay now. Sometimes we stay until like 11:00 when it closes.” (Student L)

The studio differentiated itself as a place to work alongside with peers with face-to-face. The practical concerns like more working space and facilities were secondary to these social opportunities. Being in place in the studio thus had two connected dimensions - a social dimension, and a material practising dimension in the context of the social. The material practising dimension was conditional upon having the right materials, equipment, space and the freedom to make a mess. The social dimension was supported through social media, negotiating and organising for a collective presence.

**IN THE STUDIO – OUT OF PLACE**

The studio was not an intrinsically conducive place to be. Events or other actions could quickly lead to students feeling ‘out of place’ and therefore stymied in their plans to work. Shortcomings in getting space in which to coalesce was a recurrent concern:

“... I’m sure that’s our unit space so that’s Unit G’s unit space, but sometimes...we’ll come in and they’ve taken over the whole space...so they’ve poured out into ours, they’ve spilled over into our unit space. Then it’s just like where are we meant to work? If you’re all in and they’ve got their massive A1s... then they look at you like why are you here? This is our unit space where we’re meant to work. I’m not sure if that’s actually their designated day but then they have their own unit space so I’m not too sure.... we have to go and find somewhere random, maybe downstairs if that’s empty to work...it felt weird being in that space.” (Student S)

Problems with the material dimension of working, from forgetting to bring things to the sense that the studio was not a practically amenable place, meant that some students worked exclusively at home. Student M described his perfected set-up, which he supplemented with discrete and episodic visits to the architecture studio. Beyond this interaction, he felt out of place in the studio and drawn back to his home set-up.
“Well I tend not to work in here most of the time, because I think it’s a bit messy, it’s difficult to get yourself space…I don’t think you can do it here the same way as I do it. I don’t know if it’s the best way, but it works for me…. I can’t see how that could relate in here, you’ve been to have a look at your digital model and you have to go to the model room, to the computer room and then go back to what you were doing in the workshop. Probably someone has stolen your place when you went to check something that you want to change on your model.” (Student M)

With the exception of permanent home set-ups, provision for storing things was ad hoc. The studio imposed an almost itinerant work-style:

“Quite a few people have their own [locker] …or we have a little space where our models are, sometimes I just put my stuff behind there, hidden behind the models or something so if I need to get it I can come in the next day and just take it. Or our portfolios are all stashed at the bottom …or I just put it in someone else’s locker and then they’ll lock it up for me. Nothing important, it’s just usually work. I won’t leave my laptop or anything. I’ll just leave my sheets of work or a roll of paper that I’ve used or my model if I don’t want to carry it home and then bring it back.” (Student S)

So the qualities of being in-place came down to the degree to which they could invite and hold social and working practices. Variable occupation, negotiate through both prior practice and use of social media reflected the studio’s role as a social milieu:

“…10:00 in the morning onwards we are supposed to come in… 10:00 on the dot no one is there, myself included…People filter in through the day. Generally, you will get a certain group of people who will be there from like 11:00 or 11:30 onwards to 7:00 at night. Then you will get a second group of people who will come in for their tutorial but then leave again. There are almost two separate groups. One is a permanent, they know they have to stay there, they know they have to work and that it is easier to work there, and they do that. Then there is another group that just filter in and filter out according to when their tutorial is.” (Student L)

Students struggled to confer onto the space enduring markers of ‘in-placeness’. Student S, described her first experiences of studio work in 1st year:

“It changed. Sometimes it would be at the far end of the room. It depended as well how many – because our work was individual but we had like a group of us to one tutor. If most of the group was in, we got a bigger table. I guess if another group, there weren’t too many people; there was less of them so they made a smaller amount of space, kind of thing. It changed. If everyone was in, then it got a little bit … so sometimes we’d have to use a little bit of the space next door.” (Student S)

Working in the studio required the planning of set-ups and the organisation of things; It was an uncertain space when compared with converted living room tables and bedroom floor.

However, in the social dimension, the studio acted strongly in enrolling the community:

“we have like a group you know on WhatsApp like we have a group, like conversations so we’re like texting between us like the studio people all the time like where are you, what you’re doing… what time you’re going...” (Student A)

The ‘studio people’ would co-ordinate their studio presence, agreeing when to go into
Using studio facilities was seen as an investment, requiring effort and planning, but one that was rewarding. They could describe how the design studio should work in theory, but negotiated their own, often-vicarious patterns of attendance and participation. One student advantageously compared his own investment in studio working with others who were marginal participants:

“They always look unhappy when they do finally arrive. It is because... they are not enjoying it because they are not getting fully into it. It just becomes something they don’t want to do but have to do in a sense which kind of defeats the point of being here...” (Student L)

When you are all here you can bounce ideas off each other and if you don’t know how to do something someone else might. Then you can, you learn a lot more if you are in the studio working with other people rather than being at home. (Student L)

PLACE AS FIELD

Bourdieu’s model of habitus, field and capital offers further a useful framework for considering this condition. The social milieu of the studio provides a scene for the practice and display of ‘practicing’. It is a kind of field where this practicing-capital can be accumulated and displayed. It is a property of the social milieu rather than the space, so working or practicing in the company of others (in space and through social media) becomes a more valued aspect of studio than simply space or facilities.

This practicing-capital is linked with the acquisition of a habitus of studio culture, the transformation of physical practices or habits into social dispositions. The studio milieu had value even to the isolated home working student: Student M described his need to come in and see what other students were doing, and with much effort to work for short periods in the studio space, as a kind of gesture and display.

Being in place in the studio allowed opportunities to practice externalising hitherto internalised knowledge. And what is important here is that this externalisation needs to happen in a social context for social capital to be acquired. Student L described students who didn’t appear in studio as disengaged, as having nothing that he would want, no social capital.

In the days before a crit, Student L noted these students’ increased presence in the studio. This can be read as the student’s need to explore the field, trying to acquire more social capital.

Being in place in the studio (as opposed to being in place at home) required negotiation and had costs, but despite this, the students were prepared to do it. The social milieu allowed them to pursue practicing-capital (in Bourdieu’s terms, to be better at doing, more efficient); a symbolic capital alongside the social capital and cultural capital (know-how).

The teaching in the studio offered an extension to this field, giving the students the chance to accumulate more (and more distinguished) capital through events like the crit.
CURIOSITY

THINGS AND EVENTS IN PLACE

Things acted as gatekeepers to the design studio: having them signified belonging (I have these things, I am an architecture student) and using them signified doing, practicing. Whilst a lot of this went on in private, the social dimension was for all the students interviewed, an indispensable element. Even for Student M, the committed homeworker, a stint in the studio was a chance to practice in a social milieu. So having and using things were not just practical and material issues, they had a material and social dimension that was most clearly evident in the studio setting itself. Students who used the studio to work in could trade their know-how; display their things, techniques and working processes.

Drawing from Bourdieu’s conception of practice, this activity can be read as a mechanism for externalising by practicing modes of doing. Students who worked in the social milieu of the studio were “getting a feel for the game” by exploring the limit or boundaries of the field of studio culture, believing in it, and its “sensible” practices (Fuller et al., 2005).

The crits came as apogee moments in their field. For the confident students, it was an opportunity for them to have their work recognised by students, staff and external ‘professional’ members. This was not just about the recognition of the value of their work, it was, through the inter-subjective nature of the crit, a process of participants giving and accumulating capital from each other. This capital took the form of knowledge, cultural or ‘practicing’ capital, and social capital. Student L described his skill in leading his crit audience, whilst Student S had hers at the end of the day with only one friend to watch (after it had finished it was late and she said the tutors left quickly with the guests).

DEGREES OF ENGAGEMENT

Around the formal teaching like the crit and the tutorial, there were meetings on social media, informal agreements about staying and waiting for friends to have had their crit, and social get-togethers like going to pub. These were student initiated, informal and ad hoc:

“It is a reflection on the day. Generally, we just point out what everyone has done really well and just try and shy away from the negatives. We let the alcohol do that. But yes, it is a mixture of commending each other and slagging off the tutors, like saying what you thought. If you think they are wrong on something, then you discuss it at that point.” (L)

Attendance at these events was limited. They were not embraced by all members of the group, and although the students wanted their tutors to come along, there was some awkwardness about how the community could embrace them. Students struggled to recognise others who were either peripheral or non-participants even when this description fitted their own pattern. Student F described the exhaustion of working up to the crit, of staying to listen to his friends present and then immediately going home. Student M was more open about his responses to the crit:

“I normally try to stay if I see that I’m hearing interesting things, I stay until I get bored and then I go...”… (Student M)

CONCLUSIONS

The study indicated that design studio culture involved a network of elements that supported learning; much of it situated outside formal structured teaching. The analysis used Bourdieu’s theory of practice to further the consideration of how the students developed their practice. The process of internalising and embodying studio habits and learning studio habitus took place mainly outside of structured teaching, so peripheral students therefore lost out in their opportunities to develop habitus: Student M didn’t see
any point in sticking around after his tutorial as he knew he wouldn’t see the tutor again for the rest of the day, whilst L got that studio culture was a kind field for testing out where he was at, and saw non-attenders as outsiders to this.

The research highlighted some very straightforward practical problems to do with the need for things, inhibiting studio use and as a consequence reducing involvement in the social milieu of peripherally engaged students. Such students also drew back from the pressures of performance in the social setting. This suggests that there are opportunities to advance design studio culture by broadening participation in the notional community, challenging marginal participants who stand at the boundary of the community avoid engaging in ‘the game’. The tutor has a possible role in stimulating and extending the notional community even though they cannot themselves be insider participants. They can encourage reflective talk by recognising that participation in community is not just a support network, but site of learning through practicing in a social arena.

REFERENCES


Frederick, M. 2007. One Hundred One Things I Learned in Architecture School, MIT Press.


Hughes, J., Jewson, N. & Unwin, L. 2013. Communities of Practice: Critical Perspectives, Taylor & Francis.


The studio as site: Exploring the positionality of the designer in the creative process

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INTRODUCTION

There is a well-established critical discourse surrounding the experience of architectural imagery. Robin Evans, as a key example, tells us of the performative qualities of our engagement with representation, and of how in this engagement we think spaces into architectural imagery and objects in a “generative act” (Evans, 2000) that might be itself considered as the production of a spatial event. This discourse demonstrates a conceptualisation of architectural (and art) criticism that incorporates and embeds the observer and representation into a generative dialogue, in which architecture is understood as a shifting and interpretative meeting of the coding and phenomena of the image with the subjective positioning of the observer. This paper will, on the one hand, engage with this understanding of architecture as, in-effect, produced through its interpretation, and will look at the potential this unlocks in the consideration of architectural images and objects. However, while this concept has been furthered and utilised by many theorists and designers since Evans’ writing in the 1980s, there are aspects of our engagement with architectural representation that have often been over-looked or are under-theorised. One such aspect, and one that this paper is concerned with, is the nature of our engagement with architectural representation during the process of its production. We view this as particularly relevant given the radical changes in the production of architectural projects since the 1980s, and in this paper we discuss projects – from our practice and pedagogical approach – that focus on the nature of our engagement with them during their production.

A second and vital consideration for the projects in this paper is with the nature of the space in which we engage representation – the space in which both observer and representational artefact are contained and the interpretative performance described above takes place. We begin by attempting a definition of the qualities of this space, which we refer to as the studio. This complex space is one in which immediate material conditions are merged with the figurative and abstracted spaces contained within and – significantly – between representations, and between representations and ourselves, and it is a space that is also engaged with (often simultaneously with the representational artefacts it contains) through its observation and interpretation.

STASUS, our design-research practice embedded within the Architecture Department at Newcastle University, concerns itself with the nature of this
space and how we act within it in the production and interpretation of architectural works. Through our projects and our pedagogical approach, we examine the position of the observer in relation to the architectural project and the space that is generated around the experience of its engagement. We view the studio as the site of the design process: a site which embeds and enhances projects and gathers and transforms their ostensible and distant sites and critical contexts. Newcastle University’s MArch programme is centred on a diverse range of research-led studios, within which we have led a range of thematic explorations based on a critical interpretation of the nature of this studio space and our engagement with it. We are particularly concerned with two modes of production: of the architectural project as a continuous dialogue between representational artefacts and their observation within the framework of the studio; and of the production of space and meaning involved in the generative act of their interpretation. The studio in this mode of critical study is both the space of design production, and a placeholder (to take the compound word literally) for the complex intertwining of spaces, meaning and potentialities that this involves.

DEFINING THE STUDIO

The studio is something of an unknown in architectural discourse. It is a “key site of architectural production, yet it is not often thematised or reflected on in any rigorous way” (STASUS, 2012). As a site of production, it contains and holds the architectural project in process and completion, yet, unusually for a discipline concerned with the production and nature of space, it is not a clearly defined space in itself. It is the space in which design comes about, and through which decisions are made, a “practical assemblage, a mechanism of statements and visibilities.” (Deleuze, 1988). In the studio, the observer moves from an outside position to a necessarily integral part of the dialogue that constitutes a design process. Visual relationships, often accidental, are created between elements of projects (and between separate projects) that may hold little in common, but which are united by their presence in this space and the observer’s engagement with them. Something arguably unique to the discipline is an intensification of both the need and pleasure in reading between disparate representations, so that, for example, the plan and the section can be read together to generate a space with the engaged imagination:

“[this] combination of information from several different drawings – for instance the plan in combination to the section… [is] a suspension of pleasure that produces desire… leading to a slow blossoming of the design structure in the mind.” (Haralambidou, 2013).

This is the basis of the reading of architectural representation, manifested in project reviews in architectural education (informally referred to as crits), but it is also the continuous relationship established between designer and the representational modes employed in the studio; a reciprocal navigation and negotiation of the space(s) between representations, both contrived and accidental. In our practice and pedagogy, we attempt to maintain a conscious elevation of the processes by which designs come about, and the suspended pleasure of allowing room for, and expanding, the space between the disparate elements of these processes, by drawing attention to the nature of this space, and holding it as the site of architectural design, as opposed to the hidden mechanism behind it.

“The studio thus appears as a kind of space of transmission, a space through which something has to be sent, which would suggest that to admit it into the architectural project, and to welcome its effects, would be something akin to welcoming interference on a telephone line.” (STASUS, 2012).
To allow this interference is to become aware not only of the relationships between the constituent elements of an architectural project, and a design process, but the seemingly hidden structure and agency of these relationships. It is necessary to confront these agencies; to position oneself as one of them, and an observer of them. Only by admitting this key space into consideration (for us the most important and least studied space in the discipline) can we move from the misdirecting ‘neatness’ of conventional architectural engagement and criticism (in which our agency as observers is subsumed by the coding of the image(s) and their coercive capacity to enforce a way of being read) to a more careful and considered negotiation of meanings, a critical and performative, generative dialogue that allows us a position on a shifting, assembled surface of affect and make decisions about what is being communicated, and what we want to “make” of it.

**DIGITAL AGENCIES**

In the past 30 years, the studio as a cohesive space in which the designer operates with a fixed and specific bodily relationship to the representational media within has shifted into a space in which representations exist at a flexible range of scales and states, engaged with a fragment at a time. This dissolution of the studio as a material environment that contains and holds the author of design work in a clear relationship to the design work has had multiple consequences. One has been the reduction of significance in the action or gesture of engaging with representations, and in particular multiple representations. This is largely the result of the number of digital processes the designer engages with in the production of architectural projects. As decisions are made through CAD, the project becomes responsive to the agency of the programmes used and the controlled nature of the spaces they operate in. In brief, one consequence of the move to digital production is a reduction of the capacity to observe or experience multiple elements of an architectural project at any one time.

One response to the digital, rather than capitulating to its fragmented and disconnected coding of spaces, might be to re-evaluate and give greater potency to the spatiality of the studio itself, with close attention to the configuration of its many parts and our relationship to them. This would help balance and combine the Cartesian rules and obsessions of the digital and its capacity for extreme – arguably excessive – precision (Hughes, 2013) with
other constituent parts of a work, which are interpreted and understood in other ways. This spatiality can only be considered if meaning is attributed or acknowledged to the relationship between the digital aspects of a project and its non-digital counterparts. If these things are positioned in a dialogue, we can position ourselves in the space between them and observe and interact with them equally. This necessitates a shift from the priority of our focus away from the individual representations that normally preoccupy us, and concern ourselves instead with the structure of the design project itself as a spatial configuration; a contextual field that engages varied elements of a work with each other, with ourselves, and that demands an embedded understanding of the whole and our position within it.

ANIMATE LANDSCAPES

Our project Animate Landscapes, published as Pamphlet Architecture 32: Resilience in the long-running series, was the foundation for our interest in the studio space. Our site for this project was an uncertain territory in Wola, east Warsaw, akin to us as a location of Andrei Tarkovsky’s Stalker, abandoned train carriages sitting as blackened husks in the November fog. The vacancy and stillness of the landscape reverberated with a sensation that the serenity of the place was under threat or was an illusion. In order to capture the complex qualities of this Zone, somewhere between tranquillity and vulnerability, it seemed necessary to search for an appropriate representational mode. It became apparent to us that the best way to work with these qualities in our studio in Edinburgh would be to work with found objects – physical fragments that resonated with the landscape in some way, while at the same time enabling and encouraging the possibility of new meanings layered on through observation and interpretation.

For us a metronome (Figure 1) acted as a vessel for the landscape; preserving its qualities through its symbolisation of time and stillness. The metronome acted as the first in a series of objects (Figure 2) that we introduced to represent the landscape in Wola. In the collection of these objects – “precisely the kind of fragile, intimate objects… that disappeared with the systematic erasure of domestic space in Warsaw’s mid-century trauma” (STASUS, 2012), layers of meanings were curated and coerced into dialogue with each other, and us, through their manipulation and transformation, the studio space we occupied began to fill – or became possessed – by a new type of territory. In the collection, “time is not something to be restored to an origin, rather, all time is made simultaneous or synchronous within the collection’s world.” (Stewart, 1984). Together, in the studio, the collection formed a cohesive entity. The project that emerged through them (Figure 3) allowed the observer (and ourselves as designers) to drift through scales – the immediate scale of the object, and the scale of the representation they held – as the space between and around them is negotiated. Instead of looking through the space and discounting its properties, we are embedded within it, and the space of the studio itself becomes infused with the meanings and potentialities of architectural representation it contains.

We can no longer assume the space is neutral; it becomes part of the architectural work. The individual framing of architectural images breaks down and we enter a space which becomes in itself representational. The meanings and codes we associate with everyday objects such as a chair meet and mingle with the phenomena we’re looking for in representational devices, images and models; urban topographies mix and meld with shadows, scratches and dust on the surface of the studio floor. This space allows itself into the generative, performative act Evans describes as the reading of architectural images, in which our imagination allows structures to blossom. Rather than a notionally neutral framing of these images, as we conceivably might find in the art gallery, we allow the
space around the objects and images of the project to interact with them and enter into its language. By accommodating this territory, and ourselves within it, the project becomes as much about the spaces between representational devices as the spaces behind the framing of representational devices. We step into the project and are surrounded by it - “… the project is a dream of things in which the viewer plays the role of the dreamer.” (STASUS, 2012).

ERASURE OF SUPPORT

Animate Landscapes embodies for us a model of the studio – the space around representational devices – that can heighten the experience of architectural projects through its admission into the work, in both its production and critical interpretation. Landscape in the title refers less to the expansive site in which the project notionally operated in Wola, Warsaw, and more to the condition of the studio space in which it took place. A landscape in this sense isn’t something to be observed, or even comprehended, exactly, but is more closely related to “the dream of things”. Lyotard discusses the true experience of landscape as “an erasure of support” and “a vanishing of a standpoint” (Lyotard, 1991) in which expanse overwhelms and disorients the observer. By admitting the space in which critical interpretation takes place into the contextual field of the architectural project, there is a usurpation of conventional critical roles and normative modes of understanding architectural representation, and a subversion of our expectations as critical observers. It is destabilising, and potentially dangerously so: without a clear relationship between observer and observed object, a critical interpretation may end up
impossible. The blossoming of design elements in the mind may never take place, due to the instability of our observation: without the limits of the work clearly demarcated, the critical position we hold from which to observe work risks being untenable. This is why, after all, the studio (or any space in which architectural representation is held and examined) is usually discounted in a reading of architectural projects in favour of a clear framing of architectural imagery. What we propose (and what our projects attempt, alongside our studio teaching) is that the admittance of this space has to be managed in a particular way. It has to be designed in the production of projects. In fact, the designing of this space and our relationship to it is a means by which to thematise and propel architectural design.

For Animate Landscapes, the coding of this space was derived from the relationship of our collection of fragile objects to Warsaw’s destruction in World War II. The fragility of the pieces, and their material condition, spoke directly to an absence at the heart of the city. In acknowledging this, we could communicate aspects of Warsaw’s material histories through an interaction with and manipulation of the material conditions of the studio. In this way, the observer of the project is made aware of the studio’s potential as allegory for the material condition of the city, and the resulting experience helps frame the relationship of observer and representation. In the following projects and studios, this coding of this space and the relationship between observer (designer) and representation is always of key significance. It is a theoretical framework embedded into our work on a more fundamental level than the aesthetic concerns that often guide architectural image-making. In one sense, it is the ambition of this work, in its acknowledgement of the space around and between architectural representations, to allow us to design this space as a critical part of the production of architectural projects, and to programme our engagement with the project both as designers and critics. In other words, to design the spatial framework in which the performative act of interpreting architectural projects takes place.

EVEREST DEATH ZONE

We tasked ourselves to utilise this conceptualisation of architectural representation to address spaces far beyond the notional remit of architectural representation. This is more a question of experience than size – as the tools with which architectural designers operate have always been able to convey and image vast differences of scale. More recently, narrative architectural projects have made extensive use of allegory to reflect and communicate ideas using traditional story-telling techniques. The novel has been widely used as the basis for architectural projects, through key texts such as Alice in Wonderland and Gulliver’s Travels, and cinematic concerns have more and more become a key component of architectural schools and pedagogical approaches. While we are attracted to the potential uses of narrative derived from these forms in architectural projects, we are attempting to dissolve the limits of the framing of representation through an acknowledgement of the role of their critical interpretation, and the space that is communicated. Because of this, the novel or film aren’t ideally suited for our studies as both tend to discount the action or gesture of reading or viewing. Instead, we look to forms in which the observer is regarded more clearly as an active participant: the art installation, and performance.

The International Necronautical Society’s manifesto, published as an advertorial in The Times newspaper on December 1999, reads among its aims: “Death is a type of space, which we intend to map, enter, colonise and, eventually, inhabit.” (Crichtley, McCarthy et al., 2012). In our project Everest Death Zone, we attempted to realise this ambition through the mapping and inhabitation of the space of death in relation to some of those
endeavourers who lost their lives ascending Mount Everest. We started by producing a representation of George Mallory’s ill-fated attempt to scale Everest’s summit in 1924. Mallory and his climbing companion Andrew Irvine were the first recorded deaths of over 200 people who have died in the Everest Death Zone. In this permanently frozen terrain, which exists 8000m above sea level, is a kind of purgatory for those who were unable to ascend, literally – perhaps also figuratively. Our image attempted to capture this merging of body and landscape through an analysis of the events that led to Mallory’s death, and the ambiguity surrounding the possibility of his summit attempt: did he reach the top or not? The image (Figure 4), appearing as a black cavernous vessel, represents the position of Mallory’s body when it was discovered in 1999. It depicts the view he would have had towards the summit from the location of his body alongside the last recorded photographs of him in relation to it. The surface of the mountain itself is abstracted into a limitless wireframe mesh.

The bodies which occupy the Everest Death Zone, each frozen in the moment of dying, undergo a form of transcendence. In this permanent expanse of whiteness the landscape is a kind of void, and the frozen, human forms are all that remains of highly specific moments in time and space. Their specificity is born from their preservation and the bodies often take on new roles as landmarks as navigational aids for the living. Individually, they tell us a story of their death and, collectively, in their persistence, they map a landscape of a unique mode of dying: for some horrific, desperate and lonely and for others, perhaps euphoric. Charting Mallory’s endeavour, a map was created which conflated key events of the ascent with the geometry of the mountain. The result was the creation of a space that recognised death not as a static event, but instead a field of specific moments that exist around death. Such a representation is not possible in itself, but is possible through a performative interpretation of the image. By positioning the observer in the role of Mallory, we are able to act out his death and understand the landscape and his relationship to it in a new way. This works to some degree with a performative reading of the image, as it is understood in a particular way when the thematic is revealed and the reference made clear.

Everest itself plays a role in this understanding. The mountain, so heavily visualised and embedded in the cultural imaginary, is inescapable – for these unfortunate climbers but
also in the wider sense that it appears so determinate as a thing in itself. The silhouette of
the mountain, for example, is immediately recognisable, and the cultural associations of
Everest are well-understood: the insurmountable task, the near-impossible challenge of a
“personal Everest”. By conflating Mallory’s failed attempt with the surface of this symbolic
landscape, we are forced to attempt a deeper reading of Everest and its implications. The
body, depicted in the drawing as a black smear on the landscape, is suspended in the
abyss of the unknowable and heavily abstracted mountain. The transformed body itself,
known as the subject through the image’s title Mallory, appears through its formlessness,
like a disfigurement of the corporeality of the observer – “the panic comes from the fact
that the narcissistic imago of the perceiver has been attacked” (Bois, Y.A. and Krauss, R.E.,
1997). The familiar form of the mountain is also gone, replaced by an ambiguous terrain,
although the mountain’s recognisable silhouette is visible within the photographs in the
representation, dwarfed by the body-form. We are invited to inhabit the space surrounding
the death and to meld, even transcend, into the landscape like Mallory and the other
endeavourers of the Everest Death Zone. In this way, we too become part of the event and
part of the landscape, becoming inhabitants of the space of death. We are performing
a reading of the spaces suggested in this representation, through our understanding [or
lack of] of its associations: Everest, endeavour, mortality, etc. We are caught in a moment
of understanding that constitutes a different kind of landscape, to return to Lyotard’s
SCAPELAND, in which landscape is understood as an erasure of a support. We are not
attempting a description of this landscape, but a form of “the writing... of the impossible
description; DESCRIPTURE.” (Lyotard, 1991) This allows us to take a position and – if only
fleetingly – glimpse or even inhabit (as the INS propose) the space of death.

The next stage for this project translates the drawings produced into an installation in the
studio: a space in which elements of the image are re-formed and inhabited (Figure 5)
and the original image is, in part, reformed through shadow and projection. Working with
students in Newcastle University’s innovative Linked Research model, the installation allows
us to reflect on the Mallory-object as a container or vessel for a body. We can enter it and
from within, observe the summit through its representations in the film The Epic of Everest,
using footage from the original summit attempt and recently restored by the British Film
Institute.

LANDSCAPES OF HUMAN ENDEAVOUR

An MArch studio developed from Everest Death Zone at Newcastle University, titled
Landscapes of Human Endeavour, which furthered many of its themes while allowing
students to identify their own endeavourer (and associated landscape), and so explore new
ways of interpreting both through the performative framing of architectural representation
in the studio space. The projects were varied and fascinating, ranging from a project based
on Donald Campbell’s doomed water-speed record-attempt on Lake Coniston (Figure 6),
to Michael Collins’ solitude orbiting the far-side of the Moon in the Apollo 11 missions;
a project which developed into a printed data-landscape held at a Lagrangian point in
deep space (Figure 7). As with Everest Death Zone, these projects were installed in often
complex ways. Most interesting, perhaps, was Alicea Berkin’s Architectural Biography
of T.E. Lawrence – more commonly known as Lawrence of Arabia. By reconfiguring his
experiences in the desert, and key moments from his life as described in his autobiography
The Seven Pillars of Wisdom (Figure 8), Berkin generated a series of seven forms that
surrounded Lawrence’s retirement cottage in Clouds Hill, Dorset. The forms become a
manifestation of Lawrence’s psyche, and exist in an ambiguous territory between real
and mirage afforded by architectural representation’s ‘unfixed’ nature. On observing the
representations of Berkin’s seven architectures, we are unsure if they are proposals for the
project’s ostensible site around the cottage, or whether they are fantasies projected from the windows of the cottage onto the landscape around it by Lawrence. In our reading, we realise the spaces that are being presented are in themselves a form of imaginary landscape: a landscape of memory constructs and desert imagery; haunting reminders of events and spaces reimagined into tangible forms. Our expectations are overlaid with Lawrence’s, and our reading of the landscape and of Lawrence are amalgamated. Through Berkin’s installation, which was modelled as an abstraction of the cottage in Dorset to which Lawrence retired, we are placed in the role of Lawrence (Figure 9), and we are both witness to and embroiled in an understanding of the individual, hence the project’s autobiographical nature. The work was ultimately installed in a 1:1 construction in Clouds Hill that recreated, in abstraction, the cottage and located us within it (Figure 10). The drawings and representations were in themselves ambiguous in a reading of Lawrence’s life, but also the props (a writing desk and typewriter, images from the famous movie of his life, even the relationship of the installation to his cottage with its own National Trust museum) allowed an interpretation, never clear, questioning his values and experiences, and the cultural memory attributed to him. It is the spatialisation of the project in this way that allows us to engage with its subject: we are immersed within his world, performing his experiences as opposed to simply observing them.

THE TRANSFORMATIVE GAZE

If, as engaged participants in the production of architectural projects, the space that we design in, the framing of our relationship to work, and the agencies of the modes and media we utilise all have an effect on the nature of our engagement with architectural projects, there is another aspect to consider: the nature of our seeing. Our projects and teaching have concerned themselves with modes of looking at architectural representation and we have found it helpful to explore this in relation to military agencies; adopting militarised viewpoints to reveal embedded agencies within the act of observation. When a soldier sights a rifle, it has a special significance:

“The soldier’s obscene gaze, in his surroundings and on the world, his art of hiding from sight in order to see, is not just an ominous voyeurism but from the first imposes a long-term patterning on the chaos of vision, one which prefigures the synaptic machinations of architecture and the cinema screen.” (Virilio, 1989).

The battlefield soldier of the late nineteenth and early twentieth centuries, in sighting and subsequently framing a view and focusing upon it, Virilio argues, is a precursor to the viewing that we now take for granted: the vision of the camera supplanting our own vision. For him, this served to increase “the depth of visual field while reducing its compass” (Virilio, 1989). The view framed by the soldier detaches the observer from their surrounds. This militarised view is a precedent for all technological modes of seeing. The distance that the soldier’s gaze encompasses is not simply physical space but technological: a time-line tracing the disruptions the military advancements of the 20th century impacted upon visual practice and philosophy.

In an MArch studio we ran at Newcastle University titled Parallel Military Landscapes, students were asked to recognise and adopt this viewpoint in the representation of their chosen projects. All modes of viewing the work, even our engagement as critics, became problematized by the agency of militarised sight. Our student Adam Smith presented the RAF base Spadeadam through fragments of online imagery taken of it (Figure 11). In this way, the technological vision of Google Earth was turned back on its military precedents and the resulting landscape is a fragmented, dissociated whole, filled with gaps and
impossibilities where images, pixilations and distortions collide. Smith used this reading to represent his project as it developed in Moscow, re-formatting and presenting the city as a parallel landscape of militarised views. This site operated between the technological vision of the military and the real Moscow. The city thus becomes reconstituted and a programme is violently inserted into the gaps and glitches within and between viewpoints (Figure 12). Rather than fitting his proposal into the site Moscow offers, he instead recalibrates his site, the urban context in Moscow, and his architecture along with it, into the discontinuous space offered up by the militarised sighting of his project. The proposed architecture is forced to exist within this charged space of representation, and in particular the gaps and glitches where these spaces don’t add up into a consistent whole because of the nature of the optics used. From this, the programmed areas of these hidden and discontinuous spaces became secretive and Kafka-esque; they contain the unseen mechanisms of state control drawn from contemporary discourse on Moscow. The structures demonstrate through their attempted realisation the impossible spaces of militarised sight and so
question the notional accuracy of spatial representation in the modes of vision employed by the military, and ourselves as architects. Through an examination of the spaces and references his project draws in, it becomes apparent that what we are looking at is not so much a coherent and continuous series of spaces projected onto Moscow, but instead a contextual field that draws things together into a (fragmented) whole and asks us to engage with it in the studio. By drawing attention to both the agency of observation and the seemingly familiar nature of urban representation (through Google Earth, etc.), the nature of both is questioned.

A related brief at the University of Greenwich asked students to interrogate the collection of the National Maritime Museum. Within the museum in Greenwich there is a special collection entitled Nelson, Navy, Nation, which celebrates the supposedly heroic life of the British naval officer and military strategist Lord Horatio Nelson. For the viewer, this historical exhibition represents a powerfully cohesive whole – a completeness which avoids speculation and interpretation. For the purposes of the design brief, students were asked to select a particular object from the museum collection. The intention of this request was to allow new meanings to be projected onto these dislocated objects through their close consideration and reworking. One of the students, Alex Fotherby, selected the bullet-strewn undress coat worn by Nelson at the Battle of Trafalgar, 1805, where he was famously shot and killed. On freeing the jacket from the context of the museum collection, the observer is able to see beyond the formal constraints of the garment. Instead, the jacket became viewed as something which had lost its form, and context, and is thus opened up to the observer’s projections. As the formlessness of the jacket is revealed, the hole left by the fatal bullet engulfs the viewer as the principal point of focus, moving the ceremonial appendages adorning the jacket to the periphery. Upon viewing the void of the bullet hole, the observer steps into the space once occupied by Nelson’s killer, and in taking up this positionality, the viewer begins to occupy the space of the soldier: a space of ominous voyeurism.

For the student, this occupation enabled a way of viewing, or sighting, the project that consisted of a series of drawings exploring interval perspectives towards the void of the hole from the point-of-view of the bullet. These perspectives were then collapsed into the moment of impact to generate a new hybrid form representing the visual trajectory between viewer and object. This form is the result of both the unpacking of the bullet’s trajectory and the formlessness of the bullet hole. Within this cone of vision, both projections meld together to represent the moment of Nelson’s death as a complex topological field. The inhabitation of such a space is possible on a number of levels. First, by observing the bullet hole we fleetingly inhabit the moment of death. Second, by mapping and charting this moment, it is possible to construct a spatially complex environment drawn from it. This cartography of death set up a number of spatial parameters, creating a vessel in which the architectural immanence of the project is revealed. The project became a vessel, sited in the zone between the location of the jacket in the museum collection and the passage that Nelson’s body took during his Thames funeral procession near Greenwich. This new vessel for Greenwich – a reworked monument to Nelson (Figure 13) – consists of the instances that have been mapped between the viewer and the object.

Vision and its relationship to design processes and decisions is rarely given a role as a constituent part of the production of spaces within a work. However, as demonstrated here, visual agency is a key component of critical engagement with design work. We should distrust modes and media that take our vision for granted; the ubiquitous vision of Google Earth, the internalised logic of the computer-generated perspective; and which are used
commonly and without critical interpretation in the production of architectural work. The projects above attempt to accommodate vision in its most violent form: the obscene gaze of militarised thought. As the gaze becomes spatialized, the means by which we observe the work is brought into focus. We are tainted by its associations, and the projects, and our understanding of them, reconfigure themselves around this new and unfamiliar mode of looking.

CONCLUSION

Our practice and pedagogy are constituted in zones of between-ness – the studio space that holds us, and the objects and spaces that we are observing. This space is one in which images, objects and their observation are bound together in a continuous, performative dialogue that mediates their understanding and role in the design process and its varied outputs. The space of our practice does not really exist in the spaces of the images and scale models, digital representations and collages we and our students have produced, nor in the material makeup of the walls, the floor, or surfaces of the studio. The space of our practice exists between all these things and ourselves, and is visible only in fleeting, performative interpretation and moments of understanding. Each understanding may be, even subtly, different. And from a continued process of observing, reading, and communicating with our work (and the work of our students), a studio practice emerges which is constantly transforming. It is within this conceptualisation of the studio, as a contextual field of indefinite potential in which we are always engaged with our projects and their resonances, that we produce and ask students to produce architecture.

Recently, architectural representation has by necessity been required to move beyond its traditionally static and self-assured forms. In doing so, it has opened up all sorts of questions on the nature of not only architectural representation but architecture more generally, and there is ongoing dialogue about the role of architectural education in responding to this. How do we represent spaces we know are transient using coding designed to express permanence? How do we make use of the digital’s capacity for precision, while remaining aware that the real is not so precisely defined? What is the relationship between the designer and the production of work, given the range of media and practices utilised that each has its own embedded agency? The media we use to produce and present work often goes unquestioned. However, in the discipline more and more architectural thinkers have been awakened to the capacity for architectural representation to craft a dialogue between seemingly disparate but connected things. This capacity of architectural representation as being able to image, outline and make tangible ideas is striking, and more theorists and practitioners are helping to redefine the role of architecture to focus on this spatiality of meaning. Our approach, outlined here, focusses on the space that holds representation as significant and programmable, in order to allow for a critical relationship between ourselves and our work: one that celebrates and enhances our embodied understanding of architectural spaces rather than muting or ignoring the space in which we critically approach work. Our interpretation of these representations and the contextual field that surrounds them in the studio space, and our positionality in relation to this space during the production of and in the performative interpretation of work is, pertinently for any consideration in this discipline, principally a spatial concern, and so worthy of further consideration in the architectural discipline.
REFERENCES


Stewart, S 1984, On Longing: Narratives of the miniature, the gigantic, the souvenir, the collection, Duke University Press, Durham NC.

This paper will begin by asking two key questions: firstly, why has architectural education been so resistant for so long to the acceptance of research within its own practices; and secondly, as a consequence, what is the best way for us now to get around the impasse? Historical reference will be made to the work of figures like Leslie Martin and Richard Llewelyn-Davies in the 1950s and 60s, through to the impact of critical theory, cultural studies and digital design from the 1990s, none of which however made a fundamental change in terms of the teaching of studio design in architectural schools. This paper will instead argue that it is the advent of the approach known as design research in architecture over the past two decades that offers the first genuine opportunity to create not only research-based design, but also research-based practice.

The argument will be developed using the points which the author has written on extensively in regard to how research needs become embedded within architectural practice and the teaching of the subject. The other source of evidence for the paper will come through the analysis of a specific range of architects which has been deliberately chosen to include both speculative (Lebbeus Woods, etc) and applied practitioners (Teddy Cruz, Shigeru Ban, Tonkin Liu). The latter category will also allude to the approach used by the Palestine Regeneration Team (PART) for research-based projects in the West Bank and Gaza Strip. Then, to show how such approaches apply within education, a few examples of design-based student work will also be shown.

Above all, by demonstrating and promoting the broad church that is represented by design research, and by discussing how this approach can be embedded into the educational process for forthcoming generations of architects, a range of suture opportunities will be suggested. Here the argument will be developed not merely on the usual aesthetic and pedagogic grounds, but also in regard to the general role and status of architects politically and economically. In this regard, the paper will conclude with reference to Cedric Price, who in essence first presented the case for an educational model based on design research back in the AA during the 1960s (even if that particular aspect of his work was overlooked at the time due to a focus on other dominant tropes).

**DEFINITION OF DESIGN RESEARCH IN ARCHITECTURE**

As a working definition, architectural design research can be described as the processes and outcomes of inquiries and investigations in which...
architects use the creation of projects, or broader contributions towards design thinking, as the central constituent in a process which also involves the more generalised research activities of thinking, writing, testing, verifying, debating, disseminating, performing, validating, etc. Architects have been deploying a combination of these modes of expression for a rather long time in their work: for around 500 years now, according to my esteemed colleague, Jonathan Hill.

Likewise, design research is able to blend into other more established research methodologies in the arts, humanities and science, with no intrinsic antagonism. It is vital that the design element and these other modes of research activity and research methodology operate together in an interactive and symbiotic manner, with each feeding into the others throughout the whole process from start to finish. In turn this raises an important point about temporality, in that design research should never be something that just happens at the beginning of a project, as a sort of Research & Development stage, before the architect ‘lapses’ into more normative and routine productive modes. Indeed, architectural design research, if undertaken properly, is open to the full panoply of means and techniques for designing and making that are available to architects – including sketches, drawings, physical models, digital modelling, precedent analysis, prototyping, digital manufacture, interactive design, materials testing, construction specification, site supervision, building process, user occupation, user modification, etc. Architectural design research does not of course need to use all of these possibilities in every instance, but they indicate the sorts of techniques that ought to be brought into the frame.

Design research in architecture cannot however be conceived as synonymous with the immensely broad subject of architecture, or indeed of architectural practice; rather, it is a significant seam that runs through design work with a particular focus on the creation of new insight and knowledge. Here there is a useful parallel with practice-led research in the fine arts, as Jane Rendell has pointed out. She notes that compartmentalising the four main disciplinary approaches within architecture (building science, social science, humanities and art/design) works directly against what we realise is the multi-disciplinary nature of architecture as a whole. Instead, Rendell believes that design research offers a means to bring these disciplinary strands together and also – importantly – for them then to be able to critique their own methodological assumptions. In this regard, architecture can learn a lot from the development of PhDs by Practice in other artistic fields. Yet while accepting that the influence of practice-led research in the fine arts is important, there are of course other approaches within architectural design research which stem from very different impulses: there are many types of research in design research, just as one can see there are many types of research in science or social science or history or fine art.

This then leads on to the issue of the methodology of design research. Other forms of research in architecture openly proclaim their methodological approach, for example science (repeatability) or history (transparency), while in social science, for instance, an articulation is made between theory-testing (deductive) and theory-building (inductive) approaches. Yet in each case, research methodology is not just a narrow matter of being rigorous and consistent and diligent. The importance of speculation and imagination to the scientist, or the social scientist, or the historian, is well testified. Hence the only difference with design research in architecture is a matter of degree, since in the latter – while borrowing where appropriate from the other, more established research methodologies – the creative aspect becomes the dominant part of the investigation, and to achieve that it has to introduce its own ideas of testing and evaluating, even in rather lateral or unexpected ways. Hence there is no methodological schism. Each of the other kinds of architectural
research also rely on creative leaps and lateral thinking in their methodological process, if not nearly as much. In other words, the issue of the methodology of design research as a contested site – in that it clearly opens up a new paradigm of research – is one of its real strengths.

As a key example, I am fascinated by what is, as far as I know, the first specific reference to design research in architecture, by the Finnish émigré architect Eliel Saarinen in a book titled *The City*, written in 1943 in war-time America. In the final section of his book, Saarinen postulated a scenario in which the research component of their work involved architects in imagining what a city might be like in 50 years time, and then extrapolating their thoughts backwards in 10-year jumps in order to meet up with, and thus inform, their more practical work to design projects required to construct that city. For Saarinen, it thus involved a two-fold movement that expressed well the desire of the architect to be able to imagine in different temporal zones – from present to future, and from future back to present – in their designs. It reminds us the complex and varied methods required to conceive innovative and relevant architecture.

This degree of openness – both in the acceptance of design research as a valid activity and in what it involves as an actual practice – is of course highly relevant. We know that architects, through their design work and professional practice, carry out forms of research that produce their own particular kind of new insight and knowledge. In other words, they are engaged upon a research process that is noticeably different from, yet equal in value to, the kinds of insight and knowledge from natural scientists, social scientists, historians, geographers, humanities scholars, etc. It is essential to hold this catholic and tolerant view of design research, for if there has been a weakness in previous thinking on design research in architecture, it was that they were far too defensive. In turn this caused writers to attempt to justify design research in terms of what it was not – mostly in relation to misconstrued or exaggerated notions of objectivity in the natural sciences – rather than trying to say what it actually was.

THE RESISTANCE TO ARCHITECTURAL RESEARCH

This then leads me on to the discussion of why there has hitherto been such resistance to the idea of architects’ work as incorporating what I define as design research. It is worth remembering that architecture is a subject often riven by passionate schisms: the heated ‘Art or Profession’ debate in 19th-century Britain was witness to that. Similar antagonism was also found when those who first championed the idea of architect-as-researcher back in the 1950s and 60s, of which in Britain the two leading exponents were Leslie Martin at Cambridge University and Richard Llewelyn-Davies at the Bartlett School at UCL. The Rubicon however appeared to have been crossed at the 1958 Oxford Conference on Architectural Education, which set out a vision of architecture fully embedded in the expanding post-war university world, removing it thus from any surviving vestiges of apprenticeship in practice. Architecture was called upon to become part of the ‘white heat’ scientific revolution.

The latter appeal was very much the battle cry of Leslie Martin, who founded a highly cerebral model of architectural research that focussed on land-use studies and environmental design at Cambridge, later codified into the Martin Centre. At UCL, Richard Llewelyn-Davies took an allied but slightly different approach, one that followed the American model of the Bauhaus as established over the Atlantic by figures like Walter Gropius at the Harvard Graduate School of Design, and others. At the Bartlett from the 1960s, architecture was merged as part of the expanded capitalist construction industry,
and undergraduate students were taught sociology, geography and other disciplines in the manner of an American liberal arts degree. What was missing in the Llewelyn-Davies vision was the actual process of design, a subjective and imprecise activity best left to the non-scientists at the Architectural Association and elsewhere. By the 1970s the joke was that Bartlett students could plan everything but design nothing, while the AA students could design everything but plan nothing.

The positivistic approach to design research promoted by Martin and Llewelyn-Davies, and supported by other scholars of the time, such as those from the Design Methods camp, was too reductive and simplistic for most British architects and academics. Appeals to science meant little if issues such as bodily scale, aesthetics, power, atmosphere and other aspects of architecture were excluded from the discussion. Design research was given an image of positivistic reductionism that sees certain architects to this day still denying that their work can be regarded as research, as if somehow that would drain them of any claim to creative inspiration. But one cannot simply blame scientific positivism. Later on, in the late-1980s and early-1990s, the impact of critical theory, cultural studies and digital design failed to make a fundamental change in terms of the teaching of studio design in architectural schools, since they did nothing to ensure that research expanded beyond the traditional spheres of history and theory, or technology.

NEW VISIONS FOR DESIGN RESEARCH IN ARCHITECTURE

A major impetus for a new vision of design research came from the mid-1990s with the creation of the first PhD by Design programme in an architectural school, by Philip Tabor and Jonathan Hill at the Bartlett in 1995. Their model came directly from the PhDs by Practice that had been set up in British art schools a few years before by the likes of Adrian Rifkin. Soon after the Bartlett, a different model of the PhD by Design was created on the other side of the world by Leon van Schaik at RMIT University in Melbourne, as an attempt to bring high-quality practice work into the academic fold. Today there are many PhD by Design programme in Europe and Australia, which cover a great variety of subject areas including design method, visual representation, textual analysis, social processes, and strategies for action. Design doctorates need to contain a substantial amount of serious and innovative historical/theoretical research as written text, with this being combined with creative propositions realized through a symbiotic mixture of drawings, models and textual analysis. In this regard, the actual projects might well be drawn, built, filmed or rely upon a range of other investigative media. Yet in all cases a deeper textual analysis absolutely has to be present. Indeed, it is this essential symbiotic interplay between designing and writing which creates the essential framework for a design doctorate in architecture.

Equally important to us today are the innovations in design research in architectural practice, in many cases from those also teaching in architectural schools where a strong PhD by Design programme exists. At the Bartlett a clear example of this is Niall McLaughlin, who is now trying to reshape his much-decorated practice on the basis of design research. As an exquisite example, his research process for the Bishop King Edward Chapel outside Oxford involved him in a very deep study of geometry in an attempt to find a contemporary way to link architectural design to religious liturgy, including here an exercise with those in his office to create a modernised version of the medieval tracing floor so as to get around the dull dominance of computer-generated geometries in contemporary architecture. Another excellent example is the work by Mike Tonkin and Anna Liu in developing what they call Shell Lace Structures. Funded in part by the RIBA, and working closely with Arup Engineers, their investigations have involved also research work by a postgraduate design studio they taught at Westminster University.
Outside Britain, who might we point to as coming up with new ways for design research in architecture? One obvious figure is Teddy Cruz, working (and worrying) on the American/Mexican border. Cross-border trade in legal and illegal goods has created a volatile cultural condition in San Diego, where Cruz has his practice, and even more so directly over the border in Tijuana. As someone who comes from Guatemala, Teddy Cruz is more than happy with cultural hybridity. Indeed, part of his work is to map and analyse these acts of hybridisation, whereby off-the-shelf or recycled components from the USA are recycled in the suburbs and shanty towns of Tijuana, including entire prefabricated houses. Aware of the sheer extent of self-build and creative energy being supplied from below, Cruz has a number of projects that tap into the flow, often using ‘problems’ like property rights and other legal constraints as design generators. His schemes consciously mix ideas of scale, either for contained mixed-use buildings, or for medium-scale housing districts based on the values of the individual hybridised dwelling unit. Cruz claims it is the neighbourhood, not the city as a whole, which forms the urban laboratory for the globalised conditions of the 21st century; he terms them as ‘micro-heterotopias’.

Teddy Cruz’s work openly echoes that of the late and much-missed figure of Lebbeus Woods, whose political challenge to the way in which architectural space is generated within our cities, and against the seeming hegemony of those who dominate computer-aided-design, was seminal. It was Woods who made the now common assertion that war and natural destruction, for all their terrible consequences, also enable chances for change. In this vein, a project that vividly expresses the kinds of subtleties now required by global economic conditions is the remarkable scheme by Shigeru Ban – an architect currently spending much of his time on post-tsunami reconstruction work in eastern Japan – for a ‘transitional’ cardboard cathedral for Christchurch in New Zealand. As a relatively prosperous city that was devastated by a particularly deadly earthquake in February 2011, Christchurch has insufficient funds to rebuild itself as it once was, plus it has lost about 10% of its population and it is uncertain if it can ever regain its hitherto economic status. There has also been a series of subsequent aftershocks. In such a situation there could be despair, but instead the local priest has engaged Shigeru Ban to create a cathedral for 700 people that can be erected in a matter of months and which is ‘only’ intended for a 20-30 year lifespan. The design is a work of real ingenuity, playing upon Ban’s longstanding sensitive and dramatic use of cardboard tube construction, backed up this time by ritualised visual devices such as coloured glass to give it a suitably religious sensibility.

DESIGN RESEARCH IN THE ARCHITECTURAL STUDIO

The new, inclusive and creative approach to design research is also changing and enhancing the teaching of architectural education. It is a subject that I not only write about generally, but also encourage in the students that I teach in design studio – first at Oxford Brookes, then Westminster and now the Bartlett. My fundamental principle is never to set a specific site, or a specific brief, but instead merely propose a theme that each student has to investigate themself to devise their own spatial proposition for how that particular aspect can be used to make cities better places to live.

In the research that my students carry out for their project work, there are three dominant themes. The first is to look into the ebbs and flows of the practices of daily life, as seen in Mark Rist’s re-imagination of a culturally hybrid new type of terraced housing for Soho in London, or Yoonjin Kim’s apple orchard and cider plant near Goodge Street, which would feed into a new farming cooperative headquarters in Limehouse. Second is to explore innovative energy-saving environmental design, such as the vertical hydro-powered
turbine that Yoonjin imagined could power her headquarters building, or another variant of water turbine that Jack Sardeson prototyped for the culverted River Fleet in Farringdon, designed around the properties of a Basking shark’s mouth. The third theme is to embrace the role of people’s subjective emotions, as in the sun-funnelled light within an underground workers’ bank designed by Sam Coulton in the City of London, or the shimmering park of illusions by Katja Hasenauer near to Old Street.

The above students are from Years 3-5, but the principle of introducing students to design research can also bear fruit even earlier in the educational cycle. A current Year 2 student in my unit, Peter Davies, who in what is after all only his first term after First Year, has produced an amazingly exacting sequence of studies to explore the latent ‘softness’ that can be found in the Brutalist architecture at Alexandra Road and the Barbican through the analysis of colour spectrums and reflectivity. None of this line of investigation was stipulated in the unit brief, but is Peter’s own explorations of this year’s theme of softness in the city. What this will do, hopefully, is to push this approach further in Peter’s education, as well as other students, which they can then develop over in their career to reinforce the sheer range of research and innovation created by architects.

What, however, I think needs to be added more into the mix is a closer link to political and social intentionality, to give a real driver for the pursuit of design research in architecture. I have tried in my own ways to achieve that goal. Along with my colleagues Yara Sharif and Nasser Golzari, who with me constitute the Palestine Regeneration Team, we use a research-led approach in our design consultancy for the rebuilding of disused historical towns in the West Bank. Here our explicit aim is to use architectural and urban interventions to offer opportunity and hope to a Palestinian population overwhelmed by the imposition of Israeli military power, as a deliberate means of giving architecture some genuine traction. Yet this is only to look back to a formidable predecessor, Cedric Price, whose archives in the Canadian Centre for Architecture reveal the astonishing spectrum of research undertaken for his projects, itself as an extension of the promotion of cybernetics and other trendy ideas in his AA teaching. This expansive research approach was applied not simply for the better known Fun Palace and Potteries Think-Belt, but also schemes like the Interaction Centre in Kentish Town and the Snowdon Aviary in London Zoo. Price’s work sits very much in the pioneering stage of design research, with lateral thinking and processes of investigation being treated as important as, if not more important than, actual proposals for new buildings.

Today, the development of a richer and subtler approach to design research in architecture is, I would argue, the most vital contribution that our current generation of educators can make to architectural education. The advent and gradual acceptance of the approach known as design research over the past two decades has offered the first genuine opportunity to create not only research-based architectural education, but also research-based practice. By fully accepting the broad church covered by design research, and by discussing how the approach can be embedded into the educational process for forthcoming generations of young architects, the opportunities for the future become obvious. I repeat that this is an argument to be developed not only on the usual aesthetic and pedagogic grounds, but also in relation to the general role and status of architects in political and economic terms. It will therefore stand the AAE and British schools of architecture in very good stead if they now use their collective resources to acknowledge, celebrate, and develop the innovation represented by design research in architectural education.
Collective agency: the architectural collective as an emerging model for education and practice in Brazil and the UK

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INTRODUCTION

This paper introduces the work of student architecture collectives in Brazil as emblematic of a new culture of design practice emerging in Latin America. Student collectives work in a liminal space between education and professional practice. Their proliferation and development of innovative design practices raises questions about the architectural design process and the professional role of the architect. By analysing the contextual factors that have led to the formation of collectively organised student groups, the reasons for their formation will be revealed. Comparison of the nascent yet prolific work of collectives amongst student architects touches on issues around authorship, collaboration, and participation while considering why working collectively lends itself to furthering their interests. This paper looks at the educational setting in which student work is produced compared with the professional constraints that students encounter on graduation.

COLLECTIVE PRACTICE AS AN ALTERNATIVE PRACTICE

While architects recognise that architectural production does not happen in isolation, working collectively is rarely acknowledged or seen as crucial to design thinking and the underlying core structure of the profession. The image of the sole author, the genius architect, has only increased its dominance, with architectural education and practice complicit in their support of singular autonomy (Schneider & Till, 2009). Beatriz Colomina has written extensively to dispel this myth, encouraging a shift away from “architect as a single figure, and the building as an object, to architecture as collaboration” focusing on close existing professional relationships between architects and their consultants, clients and more recently building users and the general public (Colomina, 2000). This has resonated amongst a generation of younger practitioners who are pushing these ideas further in practice by foregrounding collective action between architects within their own design studio. By radically disrupting hierarchical office structures, the contemporary collective demonstrates other possibilities for alternative forms of practice that confront the prevalent, understanding of how architecture is produced.

Alternative architectural practice refers to both design processes and organisational structures that challenge traditional hierarchies in
architecture. This has become an expanded field where architects are involved in a multitude of activities including writing, teaching, theory and construction to challenge the “regulated space of architecture” (Wigglesworth, 1996). Working collectively has become a prominent tenet of alternative practice, used in part as an organisational structure in order to support the exploration of alternative design techniques.

Collective practice has become part of this dialogue in two distinct ways. The first idea of the collective is to reconfigure the role of the architect in relation to the rest of society. In this respect, working collectively is seen as a way of engaging diverse groups of people in the production of the built environment, subverting the notion of architecture as a singular professional practice. The second concept of collective practice concerns the relationship between architects within their own office where design thinking and decision-making is distributed democratically despite differences in professional experience. By innovating new organisational structures for practice, architects are raising questions of authorship and in turn the control of the narrative that produces design. However they also attempt to acknowledge the benefits of exploiting individual knowledge and skill recognising the “sum being greater than its parts” (Vaughan, 2012).

While both concepts are identifiable in the emerging literature on alternative practice, there is little investigation of how groups are choosing to utilise the term collective in their practice. Vaughan uses historic precedents to define the collective as “people with some form of shared circumstances and intent” coming together (Vaughan, 2012). However, she also interchanges the words “collective”, “collaboration”, “cooperation” and “community”, the conflation of which reflects that there is not currently sufficient understanding of the contemporary collective to elucidate the rise and breadth of practitioners who identify their practice in this way.

THEORY OF COLLECTIVE PRACTICE

The contemporary collective has parallels with groups that emerged from within avant-garde artistic and architectural communities in the early to mid twentieth century, who advanced this nomenclature, borrowing their “chosen language” from subversive politics “with its rhetoric of moral urgency” (Ray, 2007). In this way the term collective is politically charged. It is intimated that by using such a label one chooses to align practice with a specific agenda rooted in social, economic or even cultural change (Ray, 2012). Therefore theoretical notions of the collective are reflected in and influenced by political and cultural critical theory. Jeremy Till notes this has long been the case, pointing to the way the word has been implemented to denote a number of positions from the “social, explicitly political, feminist, participatory, […] bottom up, non-hierarchical and/or cooperative” (Schneider & Till, 2008). Hardt and Negri’s term the “multitude” is useful here as it builds on ideas of who may form part of the collective, conceptualising the group as one that “produces the common” rather than is united by something in common as Till suggests. Here individuality is predicated rather than subsumed. This offers a more complex reading of the idea of the collective as groups which produce meaning and consensus as an on-going process rather than unite around a predetermined manifesto, constantly affected by external influences outside of the collective (Hardt & Negri, 2004).

This notion relates closely to the term “network” which was frequently used by mid twentieth-century theorists to combine ideas affecting architecture from outside the profession with its production. This includes Umberto Eco’s work the Opera Aperta (The Open Work, 1962) which was influential on early identifications of multiplicity and plurality in art, architecture and other forms of cultural production (McQuire, 2016).
While Eco’s writing explicitly relates to aesthetics and the valuation of an “open” art-work, where layers of meaning can be endlessly interpreted by the viewer, it has implications on the understanding of the artist in the production of the work itself. This parallels the application of Bruno Latour’s Actor Network Theory to architectural practice, where all factors that contribute to the construction of the built environment mutually constitute each other rather than exist as separate entities (Farias & Bender, 2011) making the practice of architecture part of “socially embedded networks” (Schneider & Till, first accessed 07.01.2016). By constructing ideas of collective practice around sociological and cultural texts, there is a shift in understanding about what role the architect plays in the authorship of wider society. The introduction of multiple equitable ‘authors’ and the terms in which they are able to operate thus becomes a central concern.

ARCHITECTURAL COLLECTIVES IN THE UK

The contemporary intersection of critical theory with practice echoes the effect the Humanist writing of Rudolph Wittkower had on architects newly in practice in what became the post-war Modern Movement in the UK (Borra, 2014). Groups such as Team 10 promoted a shared international discourse, albeit based on the more authoritarian framework of the Congrès internationaux d’architecture modern (CIAM). Members Alison and Peter Smithson became famed for their collaboration with avant-garde artists and alignment with The Independent Group founded at the ICA in 1953. Their Mat-building projects have been described as the “ultimate in anonymity in architecture” linking their work and that of their generation with an interest in the new social sciences (Domingo Calabuig, Castellanos Gomez, Abalos Ramos, 2013).

During the 1970s The New Architecture Movement was established in the UK from which The Feminist Design Collective was founded. MATRIX Feminist Collective diverged from both these groups by integrating specific aspects of theory with practice in order to seek better social relations within a developing feminist framework (Dwyer & Thorne, 2007). Collective practice in the late twentieth century thus became part of an alignment with political action relating to Marx’s assertion of the potential of the collective as an alternative form of capitalist production, where workers control the profits of their own labour. In this same way architects sought a greater connection to their work in order to better control the forms of power evident in its production. These groups have had a great influence on other collectives such as Taking Place and Spatial Practice Collective despite not being more widely known by a younger generation of architects.

More recently, actual examples of collective organisation in architectural practice have not emerged in the UK in any significant number. This is despite the renewed discourse concerning alternative practice and the collective that has emerged from “under the radar” (Schneider & Till, 2008). Edwin Heathcote, writing in the Financial Times recently asked, “when the authority and influence of architects are being eroded... are such collectives the future of progressive architecture?” highlighting the work of a number of collectives including Raumlabour (Germany), EXYZT (France) and Rural Studio (USA) (Heathcote, 2015). However Heathcote’s only UK example is Assemble, the architecture collective who recently won the prestigious Turner Prize, which controversially recognised the collective’s cross-disciplinary approach.

ARCHITECTURAL ACTIVISM IN LATIN AMERICA

The international collection of collectives mentioned in Heathcote’s article demonstrates that there is an enthusiasm for progressive alternative forms of practice, indicating the
collective model as important for subverting the understanding of the architect as a professional in a global context. One place where this has become most evident is in Latin America where the alternative practices of Alejandro Aravena (Chile), Teddy Cruz (Mexico/USA) and Urban Think Tank (Venezuela) have had a profound influence on conversations in the UK and Europe. Their reputations are based on how they address architectural processes across a spectrum of production from urban policy to self-build. While their work has been described as ‘activism’ rather than directly related to collective practice within their own studios, it has been linked closely with ideas of co-design and new forms of collaboration (McGuirk, 2014).

In Brazil in particular there has been a critical re-appraisal of collective practices in architecture given the fetishisation in the western media of favelas as indicative of community-led design and build. Surprisingly this discourse is being led in part by the growing number of student collectives that are working in most major Brazilian cities today. Some of the collectives are informally organised within universities working in an ad hoc manner that is more experimental than directed, while others are attempting to retain their collective structure within the constraints of industry. What is interesting is that many of them are not actually aware of each other’s practice having developed their work out of localised and independent ambitions. There is therefore not yet a coherent collective movement (of collective process) despite the scale at which it is being observed. What is significant about these groups is their shared interest in foregrounding the importance of a non-hierarchical studio structure, regardless of whether their practice also contends with social and political issues topical in contemporary professional wide discourse.

THE STUDENT COLLECTIVE IN BRAZIL

This paper covers four student architecture collectives active in cities across Brazil. They are: Mícropolis (Belo Horizonte), MUDA (São Paulo), 23 Degrees Sul (São Paulo) and ENTRE (Rio de Janeiro). Each was chosen as an example because of the range of work they have undertaken and the new forms of practice they are testing. The author conducted interviews with these groups in November 2013 and again in August 2015. The interviews explore the range of motivations for working collectively, the outcomes and impact of their activity, and implications for alternative paradigms in wider architectural practice.

Of particular interest is the dichotomy between education and professional practice. Why have educational settings become the locus of collective practice in Brazil? What are the ambitions of the student collective? And how does their design thinking translate in professional practice?

THE COLLECTIVE AND EDUCATION

Architecture schools in Brazil are complex settings for learning due to the contradictory nature of their hierarchical institutional structure, which sits in contrast to the inheritance of a pedagogic legacy rooted in architecture as a tool for democratic social change. This goes back to the foundation of the Paulista School by Villanova Artigas at FAU-USP in the 1960s, which became a site of political resistance to the military dictatorship from 1964-1984 (Leon, 2014). In defiance of authoritarian rule but somehow mirroring it, Artigas introduced a dictatorial and polemical teaching approach, which has been the model for architectural education across the country ever since. What is confusing about architectural education in Brazil then is that it promotes a vision of the architect as auteur yet at the same time teaches students a Modernist history evolved from radical socialist politics. This has led the architect Milton Braga to state, "Students are always thinking
about the city and so they have to consider the collective. This is our tradition – the social tradition of the Paulista School” (Braga as quoted in Barac, 2012) yet students are actively looking outside the university for new models of education that organise these progressive ideas in a democratic non-hierarchical setting.

Resistance to the idea of the autonomous architect can be seen in the work of the collectives MUDA (Change) based at the Escola da Cidade (School of the City) in São Paulo and the collective Mícropolis from UFMG (Universidade Federal de Minas Gerais) in Belo Horizonte. Marcella Arruda, a member of MUDA, positions their work as a process where “space is not only made by drawing… but also this dynamic that characterises the space. How can we think about a project being appropriated by the people and built by the people?” (Interview D, 2013) while Mícropolis’ Vitor Lagoeiro highlights the inadequacy felt about their education, describing it as a “frustration with what most people see as architecture or urban transformation…[which] made us want to get out of it and see what we could do even though we weren’t graduated yet” (Interview C, 2013).

Student collectives have a strong desire to construct objects in the real world, extending learning through doing and making. Working together enables this despite their individual lack of professional knowledge. Mícropolis is a core group of six students who together have directed a number of small-scale design and build projects. They frame the collective in educational terms as a form of research whereby they share skill sets to engender a greater understanding amongst the group as a whole. The lack of a client and the intentionally exploratory nature of their work means that Mícropolis have mainly used ephemeral temporary installations that could better be described as events, to engage the public as a way of shaping their own design thinking. Projects included ‘Quintal Elektronik’, an experimental occupation of a street initiated by Mícropolis in the centre of downtown Belo Horizonte where a big party was held to encourage people to consider alternative ideas about the use of the public realm (Interview C, 2013). Public space has become widely contested in Brazilian cities with local government restricting their occupation and use. Mícropolis actively engaged in this dialogue, facilitating a wider conversation with the general public in a way that their educational setting would only allow them to experience in the abstract.

Low-fi interventions have thus come to characterise the work of student collectives demonstrating a dual wish to understand the social and political dimensions of architecture applied to realistic situations while in tandem learning how to direct public engagement, construct projects on site and direct the final work’s occupation and use.

MUDA have pushed this idea further by actually living in an Occupação in the República area of downtown São Paulo. In an illegal settlement in a long disused building on Rua Marconi, the group lived with residents joining in with their everyday activities and attempts to organise a viable community. The collective’s ambitions were to help build things for the residents, lending their design expertise, but also to offer activities and events to show the surrounding public the legitimacy of the building and its occupancy. In this way MUDA go beyond their architectural training to radically rethink how their role as architectural thinkers and designers can affect a fragile community threatened by private and political parties. The collective do not position this as an architectural project but one that allows them greater access to parts of society that they are discouraged or excluded from not least by their education, despite their belief that it is these particular communities who are most in need of architectural services. Again this example reveals both collectives’ shared interest in supplementing their university education through exposure, to the lives
of the people for whom they believe they should be designing. While collectives are using live projects as a way of gaining hands-on knowledge about the application of their professional knowledge, they are also questioning who architectural design is for.

Coining the phrase “Aesthetics of the Possible”, Arruda describes the approach to design that the collective has learned from the Occupação is to “start with what you have and do the best with what you have” (Interview D). This is the complete antithesis of what students study at university, where the topics of “practice, theory, technology and design” (Interview C, 2013) are taught abstractly and separately with little concern for real world constraints. Members of MUDA and Micropolis are conscious that once in professional practice they will be expected to apply their academic knowledge to design projects, without the understanding of the complexities encountered in the actual design process. Arruda describes this as ignoring “the underlying layers of existence” (Interview D, 2013).

Working collectively is not an alien practice to the students. They are expected to work in groups in the design studio throughout their university training. The eventuality of having to work alone on their final major projects in their fifth year is therefore problematic to many. Micropolis are the first group of students at UFMG to insist that at the end of the academic year their final major project would be examined collectively. In this way their collaborative process became part of the terms in which their work was evaluated. The collective thus breached the “taboo” of the design studio (Salama & Wilkinson, 2007) by asking the examiners to consider not just what is produced by the student, but also what is learnt, a shift John Habraken outlines as a key change central to the reform of teaching practices (Habraken, 2006).

Students have formed collectives initially to supplement what they’re taught with the purpose of gaining experience and learning how to apply their skill set in traditional forms of practice. However in doing so they are developing a series of additional and alternative skills that radically change their view of the profession. This has led to their desire to bridge the discrepancy between architecture as a socially motivated and holistic practice and its teaching by scientific and quantitative means. In this sense the student collective did not evolve in direct opposition to either education itself, or professional forms of practice. Rather collectives seek to enrich their understanding of both. However, this has brought a greater awareness of the architectural student’s agency in the production of architecture, encouraged by the feeling of ownership that the act of making has on a work. A reflection on the success of their initial projects has also allowed collectives to consider how their methods might reach beyond the educational setting in wider professional practice.

PROFESSIONAL PRACTICE AND THE COLLECTIVE

The role of the architect and the sustainability of collectives as a viable model for architectural practice is a question student collectives are beginning to address as their work gathers greater external interest but also as they graduate from university. Shifting from an educational setting to professional practice and buoyed by early successes, newly qualified architects are examining whether their training can be used to challenge the norms of professional behaviour. Micropolis’ Mateus Lara sees it as likely that there will need to be a change in how they organise themselves, stating that “If we choose it as a full practice I think we might need to get more conventional kinds of projects”, although he expands upon this noting that traditional types of work are “something we would like to do as well” (Interview C, 2013). Lara demonstrates that working collectively in the university had a particular purpose that may not translate into practice. However having established a reputation before graduation, the collective has greater agency to decide the terms in
which they want to engage with traditional forms of practice.

The architecture office 23 Degrees Sul, based in Vila Madalena in São Paulo shows how a collective organisational structure can be sophisticatedly developed to maintain the ideology and agency of the group in parallel with recognising aspects of professional practice. Their studio is organised so that all involved are encouraged to partake equally. Luis Pompeo Martins, a founding member of the collective states that this allows “everyone [to...] feel they make part of the process, that they look at the final result and they see at least a bit of themselves in it” (Interview A, 2015). While there are some defined roles within the group such as project leads, these positions are interchangeable and are swapped as new work comes in. The members then do as much as they can to organise a project within a flat structure to ensure that the collective philosophy extends across partners, trainees and junior architects. 23 Degrees Sul have also found that by operating under the collective label they can extend their practice beyond architectural design projects in what Pompeo Martins calls “diffuse contribution” (Interview A, 2015). Here he refers to the research each member is encouraged to undertake to enrich the wider practice, allowing the exchange of ideas “outside of design constraints [which] is also important for further projects and initiatives”. The group plans to extend their voice within professional discourse by establishing a series of free courses on urbanism that engage the public with issues affecting the city (Interview A, 2015).

The architectural collective ENTRE is made up of a number of individuals who run their own practices yet work together as ENTRE to do additional projects that extend their architectural thinking. Based in Rio de Janeiro their early work comprised of interviews between students and practitioners. Their first publication, Entre - Entrevistas com Arquitetos por Estudantes de Arquitetura (Between – Interviews with Architects for Students of Architecture) was initiated because as Mariana Menegueti from the collective states, “we felt there was a gap in our university between the students and the professionals, the academic experience and professional life” (Interview B, 2013). The collective prepare by reading theoretical texts then come together to plan a set of agreed questions before conducting the interview. The success of this action led them to expand their interview base, asking philosophers and entrepreneurs to also take part so as to “start to think beyond architecture” (Interview B, 2013). Their focus has shifted to consider public space and the construction of the city as their central issue as it “joins all the questions, we don’t just need architecture to think about cities” (Interview B, 2013). ENTRE have organised talks and workshops specifically to engage the general public to create new methods of communication between trained professionals and those with amateur interests.

What is striking is that both 23 Degrees Sul and ENTRE focus on foregrounding research as a part of their practice. They have found ways to continue learning through creating platforms by which ideas can be shared both within the collective and in dialogue with the wider profession and the public. A tenet of working collectively in professional practice for these emerging groups therefore is the ability to further design thinking by making space for research which in some way mirrors their university setting.

CONCLUSIONS

Brazilian student architecture collectives have developed innovative design methods, using their educational environment as a testing ground and microcosm for developing alternative architectural processes that may have application in wider professional practice. This paper identified two concepts that are driving the work of collectives today: the role of the architect in relation to society as part of a professional service and the
attempt to restructure practice to encourage the sharing of knowledge in a democratic setting. In both cases the ambition is to reconfigure power relationships that dispel the notion of the architect as a single arbiter of professional knowledge, which separates them from the physical production of work.

In Brazil the recent formation of a number of student collectives across the country is indicative of a younger generation intent on testing both these concepts. While all of the collectives were formed out of a reaction to deficits in their university education, which separates theoretical ideas from actual practice, their instinct to work collectively comes as a visceral rather than cerebral attempt to consolidate their learning in practice.

What has been observed is that the collective structure establishes a democratic setting that encourages individuals to contribute their personal interests to broaden and enrich conversations. This supports a culture of extended curiosity and learning that is lost after graduation. We can therefore see that collectives are using a new form of structure to change relations between one another that replicate some of the freedoms of being a student. Continued learning, flexibility, shared risk and dialogue are some of the attributes which collectives are integrating as part of their design process in practice rather than using the model to do radically different types of work.

EXPERIMENTATION
Collectives supplement their formal training by developing experimental methodologies to test ideas linking architectural theory to projects subject to actual social and economic constraints. Through limited means, collectives established effective proposals that extended their notion of architecture beyond that of a design problem. This has had repercussions on how they have come to view the role of the architect in relation to wider society. Through group discussion and analysis of the outcomes of their projects, all four of the collectives described have begun more formally structured projects that attempt to demonstrate how architects can have an alternative voice in the construction of the built environment. What is radical is that in doing so they actually show that collective structures allow a multiplicity of practice, opening the field up to a number of different types of work not restricted to the production of buildings. Through books, magazines, lectures, exhibitions and a book group, collectives have assimilated these types of work into their everyday practice of architectural production. For 23 Degrees Sul and Entre this is about communicating what architects do and the problems that practice faces to both professionals and the general public. They are developing the notion of the architect as a publicly visible stimulator for democratic popular planning, a mediator between the amateur and those who hold professional knowledge.

NEW CULTURE OF PRODUCTION
Architectural education largely focuses on training architects to direct a design process where the outcome is a built object. Students actively sought to co-construct projects with local communities, rather than design for or in consultation with them. This process elucidated the idea that collaboration fosters a convergence of meaning that creates an alternate culture of production. The immediacy of the relationship between the students and their user group changes the methodology; encouraging people to have greater engagement with and foster a sense of ownership over the wider project. This new culture where meaning is constructed through the group, but where each individual is given a platform to learn and expand their practice demonstrates how closer engagement with real life scenarios can become a crucial part of an alternate approach to education.
BETWEEN EDUCATION AND PRACTICE

It is not surprising that student collectives have been most successful in experimenting with collective practice. All in their early to late twenties, these architecture students have the freedom to act as they have little of the same professional or personal responsibilities of a senior architect even ten years older. Due to shifting expectations that have delayed when people expect to start a family, coupled with student debt and the difficulty in affording such things as a mortgage, students are less constrained during their twenties than they are later in life. Once qualified and entered into a specific part of practice the picture changes, as a full time job and legal responsibility becomes a serious deterrent to experimentation. Yet there is little focus on this particular moment of architectural training, when student architects have the basic knowledge and skill apply their ideas in practice however are not required to conform to any professional guidelines. This liminal space is where student architects should be encouraged to formally cultivate their own practice in terms of a ‘new culture of production’. Collectives in Brazil today demonstrate that there is educational value in focusing on the co-construction of methods for collaboration within collective structures as part of their training, supporting the idea that practice itself should be considered a continual and integral form of education.

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REFERENCES

Interview A. with members of 23 Degrees Sul, São Paulo, August 2015
Interview B. with members of Entre, Rio de Janeiro, November 2013
Interview C. with members of Mícropolis, Belo Horizonte, November 2013
Interview D. with members of MUDA, São Paulo, November 2013
ABSTRACT

In contemporary academic environments progressive architects and urban designers struggle to cope with the prevalent paradigm of research, which still rests on the well-established problem-solution couple. Lately, emphasis is given to ‘research by design’ that, although it accounts for the peculiarities of design as research method, it does not break with the presuppositions in the way research is pursued. In this paper we recognize the prevalence of two paradigms in research. One that starts with a well-posed research question and seeks an optimal solution and another that originates from an ill-defined problem and potentially leads to a plethora of solutions.

We argue that neither the optimal solution nor a variation of answers secures the imperative of novelty and relevancy of knowledge that can fuel practice and academia. The methods of delimitation of research by specifying the problem a priori in the form of a research question seems to be obsolete since it suggests a research that finds its innovative trope in a space of possibilities already given by the way the question is posed. In this sense design, it can be argued, is degraded to an operative medium for the exploration of that space.

In this paper we propose a different mobilisation of design in research that aims primarily but not exclusively to question the constitution of problems and to turn that question into an affirmative proposal. In order to do this, we trace a transition from variational to differential prototypes where innovation is effected by experimenting with the problematic field and not exclusively with solution space. With problematic we identify the domain through which problems are formed. Design in this case then becomes the process of designation of a problem and the production of knowledge is effected by reframing the problematic.

Without dismissing the historical formation of the disciplines of architectural and urban design, prototypes transgress traditional boundaries and categories allowing for the appropriation of and experimentation with diverse apparatuses and machines. In this sense, not only history reads differently but also problems are constituted differentially. Operating with a curiosity to access the nonhuman, those inhuman prototypes aim to penetrate disciplinary boundaries to problematize problems and to articulate artefacts with transformative agency.

“Design research” aims therefore to respond to the themes of curiosity and participation by harvesting a multitude of points of view that form an ecology of prototypes folding inhuman and human agencies. Experimenting with
biological organisms like micro-algal cultures and technological apparatuses, ‘designed prototypes’ become processes of designation of the problem in an inhuman way. In order to articulate the argument in more pragmatic aspects we look how the practice of ecoLogicStudio has designed an urban bio-digital prototype as research medium, structuring a continuous feedback between research and practice, between design brief and research question.

Within this context design research is executed by apophatic prototypes with transformative agency for an architectural discipline yet to come.

INTRODUCTION

In academic environments and professional practices progressive architects and urban designers struggle to cope with their intellectual insights and the production, evaluation and distribution of knowledge that they create in a world that tends to slip their comprehension and it challenges constantly their conventional ideas about their disciplines. Nonetheless, as Murray Fraser (2013) has recently stated in his extensive literature review on design research “the most accepted mechanism for creating new insight and knowledge in any cultural or academic field, or of attempting to understand the past, or present or future conditions, is through research.” (Fraser, 2013) Normative definitions of research can be found in the literature but what seems to be a contemporary trend is the sharing ethos of insights that can be exchanged between disciplines. This is reflected by the revised definition that the Research Excellence framework provided in 2014 and defines research as “a process of investigation leading to new insights, effectively shared” (Fraser, 2013). The EAAE provides a more specific working definition to Design Research by describing it “as the processes and outcomes of inquiries and investigations in which architects use the creation of projects, or broader contributions towards design thinking, as the central constituent in a process which also involves the more generalised research activities of thinking, writing, testing, verifying, debating, disseminating, performing, validating and so one” (Fraser, 2013).

Murray Fraser (2013) mainly and Michael Hensel (2012), to a certain extent, have both provided a literature review of the development of Design Research in academia and practice, both of them supporting a close integration of the two. A closer reading of the books edited by the aforementioned authors reveals one of the issues that this paper is willing to discuss and to develop in order to reorient Design by Research in the coming years. The prevalent paradigm of Design by Research still rests on a problem-solution couple that is always formed and positioned within an anthropocentric or human-oriented framework. The problem is formulated in such a way as for architecture to serve the human. Research, in other words, is willing to address a human image directly by focusing on its social, political everydayness or indirectly, through technological development. It appears therefore that design as a methodology in architectural research, which operates in academia and practices, is being subjected to and capable of addressing only a given human image. That was and still is the ambition from the operational research tactics of the post-war period as ‘design methods’ or ‘design science’, to recent ‘research by design’. In this paper we recognize the prevalence of two paradigms in research. One that starts with a well-posed research question and is seeking an optimal solution continuing the premises of ‘design science’ of 60s and another that originates from an ill-defined problem and potentially leads to a plethora of variated solutions. Our position therefore leaves behind the arguments revolving around ‘design science’, asking therefore to what extent design is science and focuses on the remark that our epistemological questions are all-too-human.
In this sense we make a decision to suggest three provisional categories: that of the human, inhuman, and nonhuman not as dogmatic categories capable to explain the rather thick reality of research but as means for their respective reconstitution or for their potential replacement by other novel materialisations. Science, in this sense, is the human inquiry that is mediated by inhuman apparatuses in order to produce knowledge about the nonhuman world. If that stands as a standard approach of science that mobilised operational research and ‘design science’ then it is also suggests science as assemblages of human and non-human agents in the sense suggested by Bruno Latour (1991). What we are missing though in those understandings is what McKenzie Wark has argued recently that “The sciences cannot help but bear traces of a radical [inhuman] otherness, even when the human discourse that results is saturated in metaphors drawn from mere human and historical social formations” (Wark, 2015).

To account for those traces of the radical otherness we turn to Eugene Thacker’s (2014) definition of “weird media” and the mediation of what is impossible to be mediated that affords in this sense apophatic conception of research. Weird media reveals that it is an ontological excess to the things that we encounter and not only an epistemological subtraction as Kant’s constitution of subject object would have it in relation to the thing-in-itself. Weird media are becoming apophatic in the sense that the thing-in-itself cannot be communicated but only by negating the decision to name it as such. For that matter Karen Barad’s (2007) intra-active realism becomes operative. The ontological radical other is the inhuman for Reza Negarestani’s (2014) reading of the human labour. The apophenia therefore as the practice to assume patterns and connections out of noisy data and to draw metaphors from them gets a positive treatment in MacKenzie Wark’s (2015) reconception of Bogdanov’s “tektology” as a new sharing ethos.

In order therefore to mobilise the above-mentioned concepts we suggest to follow Eugene Thacker (2011) and cut the world into: “for-us”, “in-itself” and “without-us”. This distinction will constitute the premises upon which we will discuss the three prototypes designed as the Ecologic Studio, as cases to reveal a new direction in research that rests on the apophatic mediation of the prototypes that spans between academia and practice. The paper will conclude that the real challenge for design research is not to be found in the epistemological part of the “world-for-us” and the “world-in-itself” but in a serious consideration for the “world-without-us”.

RESEARCH AS PROBLEM-SOLVING: THE ANTHROPOCENTRIC PREDICAMENT

Horst Rittel and Mervin Webber in their Dilemmas in General Theory of Planning of 1973 opposed the rigorous and clear definition of problems under Operational Research. The epistemological uncertainty becomes for Rittel and Webber the premise for a revision and rejection of the ways that operational research posed scientific problems. Rittel and Webber concluded that the incomplete knowledge of the problem or the noise or entropy that enters into a system make the articulation of a clear and well-defined problem impossible. However, the critique that they raised to Operational Research methods was still considering research as a problem-solving process within an anthropocentric framework. Their attempt therefore to incorporate uncertainty in the problem-solving couple was simply to account for uncertainty in an epistemological way. The difference between the two approaches is reflected in the difference between logical understanding of reality and meta-understanding of reality, where we adopt the definition of ‘meta’ by Gregory Bateson (2000).

Neither the optimal solution nor a variation of answers secures the imperative of novelty
and relevancy of knowledge that can fuel practice and academia. No human being can be considered purely logical or purely creative but we all are equipped with a complex mix of skills that define our very unique understanding of reality. The methods of delimitation of research by specifying a priori the problem in the form of a research question seems to be obsolete, since it suggests a research that finds its innovative trope in a space of possibilities already given by the way the question is posed. In this sense design, it can be argued, is degraded to an operative medium for the exploration of that space. While we believe that one of the main characters of design is exactly the one of being able to bridge between logical understanding of reality and meta-understanding of reality. Rittel and Webber will frame this distinction conceptually by giving to the first instance the notion of the 'tamed' problem and to the second that of the 'wicked' problem. The wicked problem deals mainly with the uncertain and as such it is impossible to frame and define it clearly. The epistemic uncertainty of the wicked problems refers either to the incomplete knowledge of a well-defined system, or to noise and randomness that ingress into the system and therefore make impossible any prediction in advance of the course of the system under question. Rittel and Webber’s attempt therefore to incorporate uncertainty into problem-solving was to simply account for uncertainty in epistemological way.

The world becomes increasingly difficult to comprehend. For this reason Eugene Thacker (2011) in *In the Dust of this Planet* attempts to slice the world into three categories in order for him to account for what emerges as an unthinkable world. The relevance to research and to design research in particular is of great importance since it is our embeddedness in the world through which we understand it and we produce knowledge of it. The “world-for-us” therefore is our world. It is the human world that we inhabit, interact, interpret and give meaning to it. It is the world that, as Thacker observes “we are at once a part of and that is also separate from the human” (Thacker, 2011). The world-for-us is not so compliant though as we would like to think. It “bites back”, it “resists, or ignores our attempts to model it into the “world-for-us”” (Thacker, 2011). This is the world that has an agency and therefore an autonomy and it is the “world-in-itself”. The world-in-itself is however a paradoxical conception. By the moment we think of it and we act upon it then it is transformed in to the “world-for-us”. “A significant part of this paradoxical world-in-itself is grounded by scientific inquiry – both the production of scientific knowledge of the world and the technical means of acting on and intervening in the world” (Thacker, 2011). Rittel and Webber’s discussion on the tamed and wicked problems is therefore situated within this reciprocal and paradoxical understanding of the world-for-us and the world-in-itself. The impossibility therefore to create a mirror between the world-for-us and the world-in-itself is due to the epistemological uncertainty that is a result either of human beings’ cognitive limitations or due to noise and randomness in the data abstracted. The bounds of our intelligibility and the incomprehensible world haven’t stopped humans thinking speculatively beyond the limits that define us as human beings, this “spectral and speculative world is the world-without-us” (Thacker, 2011). It is only through speculation that we can create metaphors for this world. The world-without-us does not need to have as horizon the extinction of the human. It is the subtraction of the human from the world that is the world-without-us. In these three different conceptions of the world we are glimpsing the possibility of breaking the circle that the correlationist Kantian doctrine (Meillasoux, 2008) has established in epistemology and to inquire into an ontology beyond the phenomenological world.

**THE INHUMAN**

What we therefore suggest is to reconceptualise Rittel and Webber’s discussion on research problems through an additive ontology and a subtractive yet speculative epistemology. Actual entities are first and foremost patterns of relations of other agential
interactions. However, those agents although real are plunged into the world-without-us which is real but not actualised and therefore virtual. Philosophers like Alfred North Whitehead (1985), Gilles Deleuze (2004) and recently Manuel Delanda (2011) and Karen Barad (2007) have explored the ontological indeterminacy of the world-without-us by constructing respectively different speculative schemes. It is first and foremost that ontological indeterminacy that makes the constitution of the problem not only difficult, but mostly speculative. Rittel and Weber have clearly stated: “the most intractable problems is that of defining problems” (Rittel and Webber, 1973). Instead of trying to build on the Kantian limitations of correlative subject and object, that is on epistemological limitations like Rittel and Webber do, the genealogy of the thinkers that we have mentioned argue for an additive ontology, a surplus value that intervenes and problematizes the problem in its resolution.

The intra-active realism of Karen Barad would allow us to discuss an excessive and contingent ontology of things. Karen Barad, a quantum physicist turned philosopher, has argued about the role of quantum indeterminacy on an ontological level, a critique on the Cartesian narrative of substances and discreteness but also a critique on the importance on mere and given agential relations. With the concept of intra-actions and her agential realism that she has developed in her book, Meeting the Universe Halfway, Barad opens up the question of knowledge-production beyond the correlationist epistemological trend of the world-for-us and the world-in-itself that underlies most of the current research. The explicit and implicit hierarchical anthropocentrism of design research restricts the formation of problems to a set that corresponds to a general conception in which architecture serves the human. ‘Human’, in these two instances is recognised as a given
category (either as social-political or affective-parametric) that design and/or technology is obliged to address. Barad’s intra-active paradigm meshes the interactions of human and nonhuman agencies into apparatuses. An inhuman, alien, revisionary and constructive force inherent in those apparatuses cuts the world differently into novel materialisations and conceptual categories of the human and non-human that are more fictional and speculative than given and dogmatic.

It is in this sense, however, that philosopher Reza Negarestani tries to rescue this horizontality from the anti-humanist impulses by suggesting a reciprocal presupposition between the inhuman and the human, “the truth of human significance –…- is rigorously inhuman” (Negarestani, 2014). Negarestani suggests therefore a verticalism that reinstates humans’ rationality and capacity for abstraction and sees the inhuman as the spark for a revisionary and constructive intervention. The task at hand for design research is therefore not a user-oriented design research, but a design-oriented user even if that user is a heterostatic assemblage of nonhuman and human entities, that they do form apparatuses capable of recutting the world differently. It is in this sense that the call for design research of the future parts from the traditional distinction between the tamed and wicked problems, the invocation of the interdisciplinary and the call for participation and increased curiosity. Our position is that all the aforementioned, although still relevant, rests explicitly and/or implicitly on a hierarchical anthropocentrism; the ‘world-for-us’, the ‘world-in-itself’. The question therefore that our prototypes construct is to address the planet as ‘world-without-us’. In this sense the prototypes call to rethink research participation and curiosity in a non-hierarchical human-oriented world by allowing the world-without-us to refract the sensible and to recut categories creating new metaphors.


Tektology therefore is:

“… neither a theory nor a science, tektology is a practice which generalises the act of substitution by which one thing is understood metaphorically via another. It is a practice of making worldviews… the wager of tektology is that it might be possible to construct a kind of low theory whose purpose is to experimentally apply understandings of one process to other quite different processes to see if they can be grasped as analogous. It is a kind of detournement that works sideways, from field to field, rather from past to present” (Wark, 2014).

A tektological orientation, therefore, will allow us to share metaphors that emerge out of our prototypical interventions with the ambition of resonating with other efforts and to scale them up in a planetary scale, which is the domain of real change. Tektology, therefore, is about sharing, not methods and tools but new metaphors.

**DESIGN PROTOTYPE**

//STEM//

The first of the bio-digital series we are investigating as case studies in this paper was proposed for the London Architectural Biennale 2006 and subsequently was presented in the Italian Pavilion at the Venice Architectural Biennale 2006. This first prototype responded to an interest to work with urban air pollution in a way that would avoid a direct solution
of a well-posed problem. It would look at urban prototypes, which at the time we called ecoMachines, which would be on one side able to re-describe spatially and materially the architecture of our cities and at the same time reprocess some of its pollutant in an explicit manner. STEM v1.0 in particular was using micro and macro-algae from the local ponds and rivers, which were considered a problem for the local ecology and allowing them to grow into recycled hospital bottles organized in a honeycomb geometry. Architecturally, STEM v1.0 was presented as a living screen able to engage with sunlight and air pollution to generate oxygen via photosynthesis. In terms of its infrastructure, STEM v1.0 proposed a ‘transparent system’ where the capability of the screen to absorb carbon dioxide is directly reflected in the number of oxygen bubbles produced and in the longer term, in the density of macro and micro-algae present in the system itself.

STEMv1.0 continuously evolves its physical qualities; light is filtered and captured for photosynthesis, oxygen is produced and carbon dioxide adsorbed; the more the light, the more the carbon dioxide, the more oxygen production, as well as density of algal growth, which will in turn increase the screening potential of STEM itself; less light and less carbon dioxide on the contrary will correspond with less growth and more transparency.

The overall systems configuration, its liquid transparency and its breathing potential is initially defined by the radiation gradients in the space; but as the living material starts to grow and evolve, the parameters will influence each other and the system will be subjected to constant transformation and will demand artificial manipulation, or interaction, from the users.

Rather than looking at solving the problem of pollution we looked at an architectural structure that would be able to absorb pollution as part the dynamic system that defines its existence.

//STEMcloud//

The STEMcloud v2.0 series presented at the Venice Architectural Biennale 2008 and to the Seville Art and Architectural Biennale 2008, evolves the morphological aspects of STEMv0.1 as well as human/inhuman interaction – the project proposes the development and testing of an architectural prototype operating as an oxygen-making machine. STEMcloud v2.0 operates as a breeding ground for micro-ecologies found in the local water bodies such as the river of Seville, the Guadalquivir or the Venice Lagoon, while at
the same time involving the public in the breeding process. The transparency and porosity of the architectural system allows the process to be visually and materially exposed to and interfaced with the microclimate of the gallery; while STEMv1.0 present itself as an almost autonomous machine where the evolution of the system is a result of a continuous feedback machine/environment, in the case of STEMcloudv.20 the public will act as a perturbation as well as involuntary gardener of the system at the same time, by feeding the micro-algal colonies from the local river water with nutrients, light and CO2 and as a result oxygenating the gallery space. The growth process will be triggered by patterns of interaction with the public and in turn will affect these patterns with its visual effects. Multiple feedback cycles are provoked within the components of the system, with the gallery environment and within the city itself.

This extended model of systemic architecture can be understood in cybernetic terms as a multilayer crossing of feedback loops. Cybernetics provides an operational framework to deal with change and transformation, the two main defining qualities of our new ecological understanding of architecture; the starting point of the experiment is artificially defined by us and provides what scientist call a primed condition necessary to promote interaction.

The basic cybernetic set for the Seville experiment includes 3 components: the urban environments (the river ecology and the gallery space), the architectural machine (STEMcloud) and human behavior (the visitors). These systems are multilayered and diverse and they will interact in a variety of ways: in this sense we can consider the experiment as complex, the outcome of it unpredictable and the question is ‘wicked’. It is impossible to tell what kind of equilibrium will emerge within each of the 3 systems; what kind of algae ecologies will grow? How will visitors be reacting to them?

In the impossibility of control, the experiment is about communication: STEMcloud is organized to allow and promote communication among the systems in such a way that a conversation/learning process could emerge. Visitors will be transformed in ecologists, the STEM blocks into microhabitats, the gallery into an oxygenating garden or, perhaps, laboratory. The priming of the system and the channels of communication between systems have been carefully designed and engineered and can be summarized as a series of feedback loops within the more generic cybernetic set previously described.


The etymology of the word garden comes from the German Garten, the original meaning of which is enclosed or bounded space, in Latin hortus conclusus. H.O.R.T.U.S. engages the notions of urban renewable energy and agriculture through a new gardening prototype; the proto-garden hosts micro and macro-algal organisms as well as bioluminescent bacteria; fitted with ambient light-sensing technologies and a custom-designed virtual interface, H.O.R.T.U.S stimulates the emergence of novel material practices and related spatial narratives.


H.O.R.T.U.S proposes an experimental ‘hands-on’ engagement with these notions, illustrating their potential applicability to the masterplanning of large regional landscapes and the retrofitting of industrial and rural architectural types, as exemplified in the project Regional Algae Farm developed by ecoLogicStudio for the Swedish region of Österlen.
Visitors are invited to engage daily with H.O.R.T.U.S, inventing new protocols of urban biogardening; the biologic diversity within H.O.R.T.U.S is provided by local lakes and ponds; as algal organisms require CO2 to grow, visitors are invited to contribute by blowing air inside the various containers (photo-bioreactors), as well as adjust their nutrients’ content; oxygen is released as a result, feeding the other organisms in the ‘briccole’ (bioluminescent bacteria) and in the room.

Information flowing daily through H.O.R.T.U.S feeds its emergent virtual garden, accessible via smart phones; its virtual plots are nurtured by the flow of observations posted by each visitor, locally and globally, by lighting levels data streams and by human interaction in real-time. Such virtual organisms offer the opportunity for capturing and sedimenting information and cultivation practices, enriching the material experience of the visitor turned urban ‘cyber-gardener’.


The Urban Algae Folly is an intra-active pavilion integrating living micro-algal cultures. The shift, in this case, is from an indoor, almost domestic prototype, to an outdoor public folly. For us this is a built example of architecture’s bio-digital future. Microalgae, in this instance Spirulina and Chlorella, are exceptional photosynthetic machines; they contain nutrients that are fundamental to the human body, such as minerals and vegetable proteins; microalgae also oxygenate the air and can absorb CO2 from the urban atmosphere ten times more effectively than large trees.

The architecture of the Algae Folly originates from the evolution of the well-known ETFE architectural skin system; in this instance it has the ability to provide the ideal habitat both to stimulate Chlorella and Spirulina’s growth and to allow a comfortable staying for visitors.

Visitors influence the cultivation protocol with their presence and at the same time become part of a public harvesting event where the micro-algae are collected and consumed as gourmet dishes on site. The mechanism of interaction is, in the case of these two follies, more similar to the one of the original STEM than in it is to one of the later H.O.R.T.U.S series, in fact the architectural appearance and shading potential of the folly emerge from the interaction between the human/folly/environment: on sunny summer days the microalgae will grow rapidly thus increasing the shading potential of the architectural skin providing shading for diverse activities; visitors, with their presence, will in turn activate the digital regulation system which will stimulate algal oxygenation, solar insolation and growth.

In any given moment in time the effective translucency, colour, reflectivity, sound and productivity of the Urban Algae Folly are the result of the symbiotic relationship of climate, microalgae, humans and digital control systems. This prototype allowed us to evolve the material system of our bio-digital algae farming prototype so to become more integrated into a dynamic architectural and urban context.

THE WEIRD PROTOTYPE

Every prototype that we have developed and presented in this paper shares the weirdness of mediation. At the core of weird media is the idea of “the mediation of what cannot be mediated” (Thacker, 2014). A type of communication with that which cannot be mediated can only be achieved by negation. That means negating the subject-object dichotomy or the human-nonhuman one. In this sense Thacker calls us to think the prototypes not as
devices, tools, or even objects that facilitate the communication between the world-for-us and the world-in-itself but as a form of mediation that is operative between the world-for-us and the world-without-us. At the time that mediation is negated, a pure communication results that is prior to any dichotomy. We do therefore have a communication between two orders of reality.

“This is quite different in principle from the modern view of mediation given by
cybernetics and information theory. There, one has a mediation between two points within a single, shared, consensual reality. While there may also be messages, channels, senders, and receivers, in [weird] media have one important difference: the mediation is not between two points in a single reality, but between two realities” (Thacker, 2014).

Every prototype in its operation as weird media refracts its inputs by materialising new agential entities. In this sense the prototype extends the human’s sensorium domain and therefore reconstitutes an agent that is augmented and transformed to feel more than what a human subject can. This is the promise of our prototypes when functioning as weird media.

Thus every single prototype therefore constructs an intra-active ecology on its own. The folly becomes an apparatus and as such creates a platform that folds together processes and refracts new materialisations possible to create new metaphors and speculations for inhabiting a built artefact while participating in the production, distribution and management of energy. It is not an interdisciplinary convergence and neither simply an ecology of participants. It is an intra-active field that constructs an ecology of participants. The agential capacity of the prototype therefore overcomes “[t]he usual notion of interaction” and of the participation to the extent that “assumes that there are individual independently existing entities or agents that pre-exist their acting upon one another. By contrast, the notion of ‘intra-action’ queers the familiar sense of causality (where one or more causal agents precede and produce an effect), and more generally unsettles the metaphysics of individualism.” (Barad, 2012)

In this sense the prototype brings together human and nonhuman agents organic and inorganic that “do not pre-exist as such but materialise in intra-action” (Barad, 2012). The prototype becomes an assemblage of heterostatic processes that at certain points ’refract’ representations of the human and nonhuman and construct a world-for-us. In this sense the production of knowledge, although saturated with human metaphors and images, bears traces from the inhuman. The whole world becomes an intra-active-ecology in our view and prototypes become apparatuses through which the categories of human and nonhuman are apophatically constructed. The world-without-us therefore that looms at the shadows of the world-for-us is the inherent ontological indeterminacy or contingency that partakes in agential relations in a given moment. These experimental refracted moments therefore should be conceived of as a springboard not for an explanation but for a ‘what if’ experimentation with the given conditions.

Curiosity in these relational terms of intra-action parts away from the Kantian scheme of what is possible to be known. Curiosity is importance. Curiosity is to access and experiment with the way things form a state of affairs. Curiosity is not transparency. Transparency is rather an unfortunate term in that it implies a concrete reality beyond the epistemological limits of our species. Transparency is epistemological, curiosity is ontological. Curiosity needs the importance that rationality provides but also the sensing that affectivity suggests. It is through the bridging of the importance and the affect that curiosity acquires it full interventionist power as revisionary and constructive agent.

CONCLUSION

It is through this turn to ontology that the prototypes become alien and as such suggest a materialisation of creatures that not only overcome the traditional distinctions of nature-culture, organic-inorganic but open a new path to design research as problem making
prior to problem solving. This ontological turn allows us to rethink the role of apparatuses and media in the design process. Instead of researching the nonhuman world with inhuman apparatuses for the production of human knowledge, as research by design suggests, we turn that around and we argue for the importance of prototypes in research as weird media.

“The task of design research as it is presented is not finding a new or improved version of the world-for-us, and it is not to relentlessly pursuing the phantom objectivity of the world-in-itself. The real challenge lies in confronting this enigmatic concept of the world-without-us, and understanding why this world-without-us continues to persist in the shadows of the world-for-us and the world-in-itself” (Thacker, 2011). That is, the realisation that inquiry and knowledge cannot be addressed by architectural objects and apparatuses as discrete objects in the word-for-us. In the world-without-us their intra-actions materialise representations capable of having a transformative agency in the world-for-us.

REFERENCES
Drawing from curiosity: The role of reflective drawing in architectural design, research and learning

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ABSTRACT

When we draw, our hand does for the eye “something that the eye, the specific organ of vision, cannot do by itself”, says the 19th century German theorist Konrad Fiedler. In The Reflective Practitioner, Donald Schön calls “virtual worlds” the drawings that allow instructors and students to test possible solutions in the architectural design studio without too much risk. Drawing is also how architecture relates to its precedents with appropriateness, in John Hancock’s opinion. Curiosity is a common driver to all these activities as none of them are able to know their ends until their final configurations are accomplished.

Since drawing is involved in all the described processes this paper aims to study the specific reflexiveness of drawing in artistic production, design, learning, and research. With this purpose in mind, we review in this investigation the philosophical foundations of artistic visuality, the cognitive aspects of design, and the use of drawing as a historical research tool.

The pivotal notions that will guide this inquiry are the aesthetic autonomy, involved in the judgment of beauty in Immanuel Kant; visuality associated to drawing in Konrad Fiedler’s philosophy of art; the designer’s reflection-in-action proposed by Donald Schön as the essential characteristic of the artistry of professional practice; and, finally, the notion of historical precedents of John Hancock and Roger Clark and Michael Pause that assign to drawing the possibility of being inclusive and specific at the same time.

At the end of this paper there are enumerated a series of contemporary exaggerations of reflexiveness, authentic forgeries of Kantian antidogmatism, in this case in the ambits of political economy and politically motivated architecture, as a testimony of the fact that reflexiveness has been simultaneously a curse and a cure in our convulsive era.

INTRODUCTION

This paper vindicates the role of drawing as educational and research tool within architectural design process. If education is understood as learning (not teaching), a process in which the learner mobilizes all his/her intellectual, spiritual and physical resources in order to overcome the perplexity of an
unresolved question, then, both education and research have an identical vocation for dealing with the unknown. From this point of view, the differences between education and research just appear at their respective ends: education is meant to transform the student into an autonomous human being, and research to produce communicable knowledge for the advancement of the respective discipline. Research-based education, the context in which this paper should be understood, imposes that students learn from experiences that produce knowledge, and these experiences transform them into the type of citizen democratic societies aspire.

An education that involves the production of knowledge should be called reflective, as reflective education implies creativity and not the faithful transmission of pre-elaborated content. In this type of education, common curiosity and discovery are part of the inspiring atmosphere of the learning environment. Research is a constituent part of reflective education, which must be supported by verifiable methods that attend to its precise ends. This paper proposes that drawing could be one of these methods of inquiry. Even more, in the same line as German theorist Konrad Fiedler stated in the 19th century, drawing explores realms of reality and consciousness in autonomous ways that cannot be reached in any other way: “even by drawing one line or by doing a gesture that represents something as perceived by the eye one would realize that is creating for his visual representation something that the eye, the specific organ of vision, cannot do by itself” (Fiedler, 1887). Fiedler sustains that drawing, the basic artistic activity, accomplishes the kind of “stability and verifiability” (1887) for images that are only achievable by concepts through intellectual activity.

This paper investigates the role of drawing within architectural design processes. Quality of design is normally associated with drawing. Drawing is the base of experimentation that creates “virtual worlds” (Schön, 1987) in which different hypothesis can be tested at the design studio. Drawing is also essential in the “reflection-in-action” category with which American philosopher and educator Donald Schön distinguishes practice.

The notion of reflectiveness associated with drawing is the umbrella under which practice, learning, and research are studied here. Reflective means a type of intelligence that keeps an eye in its own action all the time. It is exactly the contrary of dogmatism, which was defined by 18th century German philosopher Immanuel Kant as the “procedure of pure reason without a previous criticism of its own power” (Kant, 1781). Ultimately, the objective of this paper is to discuss the connections between drawing and the essential notions of “visuality” (Fiedler, 1887), “Reflection-in-action” (Schön, 1983), and “Precedents” (Hancock, 1986) for the benefit of learning, designing and researching.

VISUALITY AS AN ACTION, NOT A PERCEPTIVE TREAT

Konrad Fiedler took advantage of Immanuel Kant’s discovery about the active participation of intelligence in aesthetic matters. Far from the undeveloped status that previous theorists assigned to artistic issues, Kant defended that there is intelligence in art, the same kind of intelligence used for conceptual judging. But in art, intelligence determines the way the subject behaves when he/she judges a work of art, instead of determining the object itself. This is a pivotal moment in history because reason entered the realm of art without conditioning the works of art themselves. From then on, art has to be considered an equal among the supreme human expressions of science and ethics.

Having Kant deducted the participation of consciousness in the reception of art; Fiedler attempts to do the same with art production. What distinguishes Fielder’s thinking from
his undisputable master Kant is its “dynamism” (Junot, 2004). For Fiedler, visuality, the main characteristic of art, is not the result of exaggerating the visual aspects of reality, to the detriment of other senses; or even a more sentimental approach that decreases the participation of the intelligence. Visuality is something that only appears through the manipulation of the material world done by the artist. From this point of view, visuality is something that the eye cannot do or find by itself, it is not something that is already in nature waiting to be discovered by privileged minds or eyes. Visuality is only reached through the motivated actions of the artist, and drawing is its main mean.

Fiedler situates the essence of art in the sense of vision. There is nothing like art in general, and fine arts like painting, sculpture and architecture share a common visual condition that benefits from the autonomy of vision. From this point of view, vision has a potentiality that other senses do not have. Touch, for example, cannot produce any enduring effect in our consciousness as there is nothing like “verifiable tactile representation” (Fiedler, 1887) that can be separated from the object. If the original object that produces the tactile sensation is not present, the whole perceptual experience of touching ends. Vision, on the contrary, is able to capture experiences in another way: a simple sketch is able to trap something of the visual essence of reality that would allow us to consider it from the visual point of view, even without having the object in front of our eyes. Moreover, a simple profile of an object would allow us to develop the configuration of the sketched object according to the specific “sensitive certainty” (Fiedler, 1887).

From this standpoint, it is possible to establish a conscious relationship with the world that surrounds us in two ways: scientifically by naming, formulating, signaling; and artistically by representing things as seen or even by representing them “how they should be seen” (Fiedler, 1887). The reasonable doubt that emerges in this point is how to assure the rigor or correctness of an image that has been developed in visual terms? If we aspire to equate art and science, there should be a certain type of rules that secures universality or at least provides sufficient objectivity to the whole process.

Kant’s theory establishes that there are no rules that determine what and how the work of art should be. Rules are not explicit in art and they are only present in the conduct of the subject. Visuality also has a special kind of normativity that is not explicit and is not separable from the artistic activity (drawing). The norms that can be found in the artistic activity are inside our consciousness and are those “exigencies that consciousness poses to visuality” (Fiedler, 1887). Those rules are only perceivable and materialized by the work of art itself, and they are certainly part of “demonstrable physical events in the processes of perception and imagination, or that should at least be pre-supposed” (Fiedler, 1887).

Kant founded the validity of aesthetic judgment in the normativity of the cognitive powers that could not be proved. He deduced that aesthetic judgment has to have a subjective common base that has to be “the same in all men. This must be true, because otherwise men would not be able to communicate their representations or even their knowledge” (Kant, 1790). Also for Fiedler there are not explicit rules in art production, only the regularity that is manifested in the normal processes of perception. The artist can develop this specific order by paying attention, not only to his/her eyes and imagination but involving his/her whole body and specially his/her hands in a process that starts always with a visual perception. From this point of view, the artist is not any more the romantic subject that has a special sensitivity, someone able to see what others cannot see or feel; but someone that is able to “switch directly from perception to graphic expression”, from perception to action (Fiedler, 1887).
VISUALITY TODAY

What makes opportune to rescue Fiedler’s proposal today is his vindication of the idea of artistic activity as a unity mind-body. In current philosophical crisis, in which there are not new models of thinking and the old ones seem exhausted, it is opportune, once again, to vindicate a type of consciousness that does not involve the simple domination of the world. Equivalence between art and science should not mean a nostalgic yearning of the sort of rationality someone like Leonardo Da Vinci, for example, enjoyed centuries ago. In those times drawing was just a tool in the dogmatic attempt of the total rational explanation. Today, the situation is radically different: as Theodor Adorno said “the whole is the false” (Adorno, 1951). Nevertheless, precisely because cosmologies are ill-conceived, provisional and partial self-attentive notional scaffoldings are indispensable in our damaged era.

According to Fiedler, the meaning of artistic activity is based on its resistance to those “powers of progress” that “only see in every action a means towards aims” (1887). The interest behind the exhumation of Fiedler’s proposal on the 21st century is propelled by the conviction that visual curiosity is still a lively impulse able to inspire, not only the production of art and architecture, but specially its learning. Autonomy of vision has not died in spite of the exponential expansion of audiovisual in the globalized society, the other way around. Thanks to the resisting autonomy of vision: “now we see the artist beside the researcher” (Fiedler, 1887).

VIRTUAL WORLDS AND REFLECTION-IN-ACTION

Donald Schön was invited by the Dean of the School of Architecture, William Porter, to investigate the unusual atmosphere at the design studios at MIT in the 1970s. The fact that no explicit content was delivered at studios, added to the curious commitment and devotion of architectural design students, was considered an interesting and relevant topic of study. Observing the practical work of architectural design studio Schön coins the notion of “reflection-in-action” (1983). Reflection-in-action should be understood as the ideal skill of all practitioners; it is an atypical knowledge (in action) that allows good professionals to improvise new solutions on the go. Reflection-in-action explains how good professionals are able to deal with unique, uncertain and contradictory problems.

Donald Schön discovers an astonishingly flexible mode of inquiry in the specific way students and instructors act at the architectural design studio. This particular mode of inquiry is able to do things that are almost impossible in the scientific mode of research. Studio research is able to re-frame ill-formulated problems; to attend details and the whole almost simultaneously; to move freely when is necessary but to assume constrains when the contrary is true; to dialog with the situation itself in the way John Dewey describes as “transactional” (Schön, 1987). The way architects work when they design is prescriptible for all other professions as architecture “epitomizes the design professions, and designing, broadly conceived, is the process fundamental to the exercise of artistry in all professions” (Schön, 1987).

After discovering architectural design’s reflexivity, the ambitious plan of Schön is to extend its modes of inquiry to the whole educational system at research universities. In his opinion a different type of knowledge is required, an “epistemology of practice” (Schön, 1995). In that sense, and just as Fiedler does when he claims a special consciousness for artistic matters, Schön considers that the education of engineers, economists, etc. should have a way of experimentation that, respecting the scientific hypothesis probing, is adapted to the particular dynamic characteristics of professional problem solving. Thus, if scientific
research looks for truth, practical experiments, “experiments on-the-spot” (Schön, 1987), are meant to change the situation the professional works with. It is important to keep in mind that drawing is at the heart of the architectural experiments that inspires Schöns general theory.

“Virtual worlds” (Schön, 1987) is what drawings are able to build in the architectural design process at the studio in Schöns opinion. In the virtual worlds that architectural drawings facilitate “the hypothesis must lend itself to embodiment in a move” (Schön, 1987), which means that intellectual matters are translated into movements that are kept on the paper as drawing leaves traces of those movements. This sort of visual objectification permits to adapt the rhythm of the action during the experiments, makes reversible every one of the movements done, allows context to be adapted to satisfy the conditions of the experiment, and also permits to separate and combine elements at the will of the researcher-designer. Drawing is so attached to the idea of reflection-in-action that “the sketchpad is the medium of reflection-in-action” (Schön, 1987).

The problem of legitimacy is an important aspect of the particular experimentation that architects do. How to know when the ends have been accomplished? From the pragmatic point of view, the validity of architecture lies on the correspondence between drawings and building possibilities: “the validity of the transfer depends on the fidelity with which the drawn world represents the built one” (Schön, 1987). The representational potentiality of drawing in architecture is limited to building in Schön’s view, no further cultural expansions like in the so called “paper architecture” (Cook, 2008; Nesbitt, 1996) in his opinion.

Apart from pointing out the different types of tutoring, the main contribution of Schön’s analysis is the key role assigned to the practicum in education (Jaime and Lopez Reus, 2013). Tacit knowledge, “reflexive thinking” (Dewey, 1912), and the particular role of past experience, together with design experience itself is what encourages Schön to propose reflection-in-action as the model of a new epistemology of practice.

Past experiences in the context of reflection-in-action deserve a final consideration. Professional problems, different than scientific and technical ones, are characterized by uniqueness. Past experiences help practitioners to see the new situation as a previous one in a sort of provisional manner in which the particular characteristics of the new situation are too many and too much to be regarded. The following section discusses specific relationships between past experiences and drawing that are relevant for architectural experimentation and research-based education.

**DRAWING FROM CURIOUSITY**

Curiosity is typically associated with processes of exploration and learning activated by the motivation of acquiring new skills or discovering new things (Edelman, 2014; Dewey, 1912). This exploratory attitude toward reality could be seen as a driving force behind the lack of understanding or state of unpredictability within creative activities. Curiosity is developed from situations associated with uncertainty or ambiguity such as design problems. Design deals with new and singular situations that cannot be addressed by applying pre-established rules. Designers do more than simply solve well-defined problems applying knowledge through technology. Rather than problem solving design process concentrates on reframing uncertain, contradictory and unique situations as a way to achieve original proposals.
In the midst of searching for innovative answers designers jump the gap of the unknown by seeing the current and unprecedented problems as familiar (Schön, 1983). Contrary to what it could appear at first glance, it is the necessity of originality what makes design to rely on precedents as source of inspiration. Schön asserts that in seeing unfamiliar situations as something already known or experienced, designers might pull out from his/her “repertoire” of examples, images, concepts, processes and attitudes (1983). However, the application of experienced rules to find the best means to reach an end is not enough because design practice does not fit the model of technical rationality. According to this, design practice consists in a “conversation with the materials of a situation” (Schön, 1983), in which the use of precedents or past examples must be connected with the current task. This means, that the adequacy or utility of new possibilities taken from the past must be discovered in action, which in turn means through drawing. The fact that drawing is involved in every design process opens the door to discuss the essential role of drawing within the study and use of precedents in design.

PRECEDES AS SOURCES OF INSPIRATION FOR DESIGN

Dewey, the true father of reflexive thinking theory, discovered that one goes back to past experiences and chooses from its complex and irreducible totality those aspects needed for making sense in front of new experiences (2005). Over time designers build their own repertoire of precedents and experiences that helps them to compare situations and learn by example. The consistency of design involves the visual consequences of “reflection-in-action” (Schön, 1983) and its capacity to improve the built environment. Designers can re-frame new situations by comparing the present design task with a known repertoire of precedents that collect similar problems or similar situations. The repertoire of preexistences becomes a continuous reference in which to trace back the questions raised during the design process. But the effectiveness of this strategy lies on the control that the designer must have over the possible choices. It involves a critical attitude toward traditional and historical knowledge.

The seminal theory of precedents of John Hancock resituates architectural work on the world of cultural forms making a basic distinction between historical knowledge and traditional knowledge (1986). Two different ways of knowing the past would define the concept of precedent: the universality and openness of history induce a superficial understanding of a great diversity of precedents, which translates into the availability of an unlimited number of architectural works of different historical periods for the designer. On the contrary, tradition involves depth of understanding and authenticity but lack of openness and no availability of choices. According to these facts, Hancock redefines precedents in a territory of exploration between history and tradition (1986). The questions to be posed are: How do designers build and cultivate their own repertoire of precedents? and how precedents are better discovered, studied and used in design?

The mentioned theory of precedents seeks to resolve this dilemma through two epistemological tools: First, the limitation of choices through selecting only portions of the past according to the present task; Second, the use of rigorous methods for analyzing the selected precedent. Thus, the criterion of functionality should be accompanied by a method of analysis that could effectively replace the lack of depth of historical knowledge and the lack of availability of tradition (Hancock, 1986). Drawing is the method, also in this case, to understand in depth a prior work of architecture and to become critical about cultural material within the design process.
DRAWING FROM THE PAST AND DRAWING FOR THE FUTURE

Drawing as the main tool for managing precedents, create visual totalities or virtual worlds able to imitate the comprehensiveness of history but preventing the limitations of the immersive knowledge of tradition. Cultural material coming from history and tradition can be critically transformed into sources of design ideas – spatial organizations, patterns, archetypal forms, ready-made principles - through drawing.

Designers use different types of representations in order to reflect upon prior work of architecture and to learn by example. In this context, orthographic drawings, archetypal diagrams and conceptual sketches become interpretations in which cultural and historical sources can be critically manipulated, arranged and included as material that inform design ideas.

In this view, drawing, rather than just an action or a tool for inquiry within the design process, is considered a rigorous method to analyze selections in an effective way (Hancock, 1986). Three modalities of drawing would define the original and fertile methodological research of precedents: Analytical (orthographic drawing addressing space, plan-organization, zones, façade compositions, spatial relationships, etc.). Experiential (sketches that involve itineraries, texture, ornament, character, etc.) and transformational, applying Derridian principles of deconstruction for manipulating form (Hancock, 1986).

In the proposal Precedents in Architecture by Clark and Pause, diagrams keep a balanced dependency to the spatial and formal essence of architecture. The emphasis that abstraction produces in diagrams is used to connect the “commonalities of architectural ideas” (1996). In this case, no context, no socio-political, no technological issues are involved, just formative patterns, design parties and archetypes are considered important as they may lead to new design ideas. No periods, no styles, no names and dates is the conscious approach to the history of architecture. The use of diagrams, understood as visual abstractions that pretend to illustrate the "architecture of the idea itself" (Garcia, 2010), has become increasingly popular in architecture since the mid-1980s. The analysis of architects’ sketches offered by Kendra Shank (2005) offers the rigor of having the drawings and their ad-hoc linguistic critique together: this makes this approach a useful instrument in training to talk about what we see. In Groat and Wang’s Architectural Research Methods (2002), the authors declare faithfulness to Kantian art’s autonomy faithfulness in which is, maybe, the most important effort done for connecting architectural design and academic research.

When drawing does not pursue visuality but it turns a communication media, virtualism is round the corner. “Virtual Architecture” (Jaime, 2002) is more related to politics than to architecture. Even considering drawing as the motive force of architecture, the virtual architectural experiments show that their focus is not space but iconography.

Defined as attacks of drawers against spoken or written statements (Cook, 2008), the socio-cultural motivation of virtual architecture generates another sense of the virtual worlds totally different from those Schön talks about. In politically motivated architecture, representation has more temporal than spatial connotations. In these cases, verisimilitude becomes more important because images have different motivations than the particular “representation as seen” (Fiedler, 1887). This type of drawn architecture aspires to illustrate utopias which, in contemporary world, have become neoliberal projects that use its revolutionary powers for keeping things as they are (Gray, 2008).
FROM PURE VISUALITY TO VIRTUALISM

Connecting reflexiveness and drawing is the itinerary with which this paper has gone from pure visuality to virtualism. The objective of the study is to show the particular participation of drawing in the seminal introduction of reflexiveness in visual arts (Fiedler, 1887); in the implementation of reflexiveness in the architectural design studio (Schön, 1987), and its use in the adaptation of historiography to the creative process (Hancock, 1986). In all these three cases, the aim has been to show the proved possibility of connecting art, practice and history with our current world.

Drawing has a proved capacity of unifying ingredients of diverse natures in a convincing manner in each of the three realms analyzed. In some cases, the simple presence of drawing appears to prevent dogmatism from taking command, and, in other cases, it looks exactly the opposite. Reflexiveness, the notion that has been always omnipresent through this paper, still remains at this point as a tricky subject, as things and their representations tend to mingle capriciously when the aims of aesthetic inquiry are not fully aesthetic. Surely implicit art rules prevent rational dogmatism, but it is also true that the typical opacity created by rules implicitness has been frequently filled with simple propaganda in most of the so-called engaged art.

In the case of the notion of reflection-in-action, which certainly cannot be considered the essence of a “coherent epistemology of professional practice” (Webster, 2008), at least it recognizes the epistemological status of vision in the design inquiry: Schön’s proposal is still the most stimulant analysis of the reflexive nature of architectural design studio, and it definitely recuperates Dewey’s claims for a reflexive education in the realm of current research universities. The perennial discomfort of architecture inside research universities has been alleviated greatly by the brave vindication Donald Schön did of architecture’s particular epistemological assumptions, among which drawing preserved an essential role.

It seems evident that dogmatism enters in play whenever the pair reflexiveness-visualism is broken. George Soros has named “reflexivity” (Soros, 1987) the main problem of
contemporary economy, as people tend to confuse their interpretations with reality itself. Other experts (Carrier and Miller, 1998; Davis and Klanes, 2003; Bordieu, 1992) consider that the growing abstraction that is affecting economy - which some called “virtualism” (Carrier and Miller, 1998) as it separates economy from society - started with business schools and consultancies and the way they spread the “cases of study” (Carrier and Miller, 1998) as an infallible methodology of intervening in real problems. Donald Shön
himself came to MIT to study the architectural design practice after being a consultant and his reflective proposal went back immediately to business school education.

We do not have a clear explanation of why drawing seems to prevent certain types of dogmatisms, as it is evident in the work of Juan Navarro Baldeweg (Navarro, 2007) and some other artist-architects like Alvaro Siza and Steven Holl. It might be that drawing’s specific completeness, equidistant from perception and intellectualization, works as a break against abstractionist and dualist temptations. The fact that even those products of architectural virtualism that hang on the walls of some of the most important art museums do so thanks to its expressive quality, revives the faith that drawing can tilt the curse or cure dilemma of reflexiveness clearly in favor of art and artistic attitudes.

REFERENCES

Cook, P., (2008). Drawing, the motive force of architecture. West Sussex: John Wiley & Sons
Jaime, M., 2000. La Dimensión Reflexiva de la Arquitectura Moderna. Pamplona: Eunsa
curiosity
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Technological progress has always been a catalyst for change in architecture. Today, technical advancements across multiple disciplines suggest a profound transformation in the production of architecture, both intellectually in the process of design and physically in the process of construction. In the context of an increasingly ubiquitous digitalisation, the related questioning of established modes of design thinking, the deterioration of conventional disciplinary hierarchies and the rapid erosion of industrial logics of production is beginning to forge new alliances between the fields of design, engineering, natural sciences and humanities. Together with the continuing progress in computational design, simulation and fabrication this opens up the possibility to fundamentally rethink the way the future built environment is conceived and materialized.

The current transformation in the production of architecture needs to be reflected in the way the next generation of architects is taught and possible futures of the discipline are researched. Educational models and pedagogies need to align disciplinary concerns with the exploration of the advancement of technological processes as novel tectonic, structural, spatial and ecological potentials, and their significant cultural and social ramifications. This calls for educational programme that are ever more inquiry-oriented, experiment-based and shaped around multidisciplinary approaches to design. Teaching and research need to encourage a conjoining conception of technological innovation and cultural production, emphasising rigorous investigation and critical reflection on the implications and potentials of technological innovation for contemporary and future design research and architectural practice. Most importantly, the enquiry of such topics need to be exposed not only as a technical challenge, but primarily as an intellectual venture, in order to reveal and explore their significant cultural impact.
With the advent of digital revolution, we are inventing new production methods, but the question remains: how can we make products with new tools without compromising achievements from the past? What are the key benefits of engaging with digital tools when working with a material steeped in history? In rethinking modes of production, the more pressing question now is how can issues of sustainability play a role?

We aim to spark a debate about sustainability in material practice, using an industrial robotic arm to build with local clay. Our project aims to look at ways in which digital and traditional clay processes could be combined. Already, a division is implied. Yet over the course of the project, what has been revealed is a far more complex interplay between what we might define as digital and manual processes, or simple and smart materials. As two practice-based researchers from the field of architecture and art, we have approached the question of sustainability from overlapping spaces: inside and outside the workshop.

INSIDE THE WORKSHOP

Our project is based at Grymsdyke Farm, a research facility, fabrication workshop and living-working space for architects, artists, designers and those interested in materials and processes of making. Set in the village of Lacey Green in Buckinghamshire, the aim of our production is exploring the essential connections between processes of design, making and place. Over the last few decades, many brick-making factories in Buckinghamshire have gone out of business bar one, H.G. Matthews. The farm itself sits on a layer of clay geologically known as “clay with flint”. Due to the large number of flints, the processes of separating out the clay deem this particular resource uneconomical. Instead, we decided to use one of H.G. Matthews’ brick-making clays, Chalfont clay. The key advantage of this clay is that it is suitable for brick-making straight out of the ground. This particular aspect suited our initial production goal: local clay with minimal preparation before loading the material into the clay extruder. Chalfont bricks are low firing bricks, typically not fired higher than 1000 degrees Celsius. This means bricks not particularly hardwearing or high in strength. With these initial constraints, the project set out to design and fabricate a site-specific fired clay-building module.

Clay in Buckinghamshire is historically used for brick making. We are mindful that clay comes from natural deposits underground and is finite in quantity. Once depleted, it is not reversible and we have content with open
scar left in the landscape. High-embodied energy is another issue with fired-clay as a material. Brick making is now a disappearing industry in Buckinghamshire. Rising cost in production drove this industry to the ground. How can we maintain our engagement with clay as a material? Can new technologies provide the answers, or maybe we should cast a wider net? One can argue that manual processes of working with clay can change, and tacit knowledge that developed over time will evolve. Or, perhaps this discourse must go beyond utility and efficiency. Somewhere between a brick and a decorative terracotta block, earth works by human or animals, there is room for rethinking design and making of architectural ceramic.

Our robotic fabrication setup is modeled after a standard 3D printer: a reservoir of material dispensed at a specific rate continuously, or with a stop-start option, simultaneously being directed following a pre-determined path. In order to dispense the clay, we chose to work with an existing pump manufacture by ViscoTec in Germany (Figure 1). Their pump works with a rotating displacement principal. It is “comparable to an endless piston, which convey the product from the suction end to the discharge end, thus building up a pressure difference.” This pump is then connected to our 6-axe standard robotic arm. Specifically in the production of clay objects, this process is identical to the traditional ceramic hand-building process with clay, also known as coiling. In digital fabrication, the paths that the material dispenser is following are often generated or derived from a 3D digital model. The thinner the dispersed material, the closer the 3D printed object is to the initial digital model. There are a few potential advantages that stand out immediately using a digitally-controlled tool. First, repeatability: a clay object can be copied repeatedly like a casting.

Figure 1 Robotic arm extruding multiple segments of clay objects. Photo credit: Guan Lee.
process but without the effort of building moulds. Second, variety: it is as easy to repeat 
the fabrication of the same geometry, as it is to build something unique each time. Third, 
accuracy: multiple elements can be assembled together to form an overall geometry with 
more precision. These are potential advantages, because the final product must be able to 
perform at least as well as its non-digital predecessors. Further, there are few well-known 
limitations in 3D printing. First, scaffolding: all 3D printed objects must self-support as 
the material builds, layer upon layer. Unsupported length and cantilever are problematic. 
Second, size: the reach of the printer itself limits the scale of buildable object. Third, 
layering: these 3D printed objects are not monolithic, but fused together with potential 
failure like delamination. The system we put together at Grymsdyke Farm aims to seek 
out these issues by going back and forth between traditional ceramic technology and 
experimental methodologies.

The first task in preparing the Chalfont clay is to determine an optimum clay viscosity for 
our pump. This has immediate impact on the speed of extrusion versus the rate of clay 
dispensing. The consistency of clay ideal for our pump in traditional ceramic terms is 
somewhere between throwing clay and slip. We consulted a number of ceramicists including 
Jessie Lee who has been working with clay for over 30 years. The general consensus is that 
the moisture content of clay is often understood through feel or touch. The advice we got 
from H. G Matthews is to test the material again and again from the process of building, 
to drying and firing. Initial tests with a series of small and single walled clay columns built 
with 5mm clay beads would become unstable and begin to collapse beyond the built
height of 100mm. Also, if the clay column itself is slanted, it cannot be extruded beyond 30-degree angle. Depending on the geometry, we struggled to build beyond the height of 150mm as one continuous build. In order to overcome these limitations, we built multiple clay objects at the same time and, after each 150mm build, we would let the clay dry for up to 5 hours depending on the temperature and humidity level of the day, before building the next section. Ceramic objects can be fabricated in parts, a teapot for example: the pot, the spout and the handle are often made separately and joined together with clay slip (Figure 2).

It is almost cliché in the industry to suggest that a sustainable practice is one which is adaptable, evolving and engaging with both traditional practice and advanced technology. Our observation so far with experiments of 3D printing clay objects is that the balance between traditional and digital processes is not easy to strike. The weight of established ways of working with clay and the material’s behaviors can be overwhelming. In traditional hand coiling, the beads of clay are pushed together and ‘flattened’ with a wooden paddle. This will ensure that the layers of clay properly adhere together. With the digitally coiled clay, it is not possible to smooth the layers over, because the hand cannot decipher the original geometry contoured digitally: moreover we find ourselves making geometry with areas not reachable by hand. In some cases, our clay object delaminates, or a visible gap develops during the drying or bisque-firing process. But, if this can be overcome, the digitally-striated pattern is a unique feature that has clear ornamental quality. One technique we employed to ensure better cohesion between layers is to set the height layer of extrusion smaller that the size of the extruded bead. But, with time, as the printing process progresses, the clay dries and shrinks and the gaps widen. This problem is exacerbated if the printing process is not continuous. The pre-determined path of the clay extruder cannot reconcile with the dynamic and plastic material.

What is sustained in using locally available material to construct our environment is not only economical and practical, but also of cultural and environmental significance. In Raymond Williams’ 1976 seminal book Keywords, he put ‘culture’ into wider context, beyond references to mere physicality of our activities, in this case, making with clay. We have also to recognise the “intellectual, spiritual, and aesthetic” developments as a way of living. The tangible artistry of making in a community by this definition is cultural. Like clay from underground, culture can be malleable, a perfect blend of “resistance and yielding”. Each and every one of us is like a fired brick, shaped to be the same but universally unique. As communities, we make architecture with bricks, bound together, layers upon layers, above ground as lore of our cultures, mirroring the vicissitude of life.

BEYOND THE WORKSHOP

Image one: a young man beds down for the night on a cement floor beside his robot. The robot extrudes rings of clay, one on top of the other. After it has produced seven layers, it has been programmed to pause to allow the clay to dry so that the structure does not collapse. The man sets an alarm every few hours. He gets up and restarts the robot. Each time it curls out another seven layers of clay on top of the dried layers. The clay dries. The alarm sounds. The man gets up and restarts the robot. Sometimes the small curls of clay extruded by the robot do not create a neat circle; the end of the ring hangs down a little. In this case, the man reaches in with his finger and carefully nudges the clay back into place.

Image two: a builder is repairing a cob wall. It is made from a mixture of clay, straw, dung, gravel, sand and water, and trodden together by humans. Every morning she arrives at the site to find that a swallow has started building its nest towards the top of the wall. There is
a curve of mud pellets stuck to the wall, eighteen centimeters wide and mixed with bits of grasses and horsehair. Each morning, she has to remove this nest before beginning work on the cob wall. She uses the same material as the swallow’s nest, but in a form more suited to humans. As the cob wall dries it will continue to breathe, responding to the surrounding changes in temperature and humidity. “Cob,” she says, “is a smart material.”

These images could represent two distinct processes that we might call new and old or digital and traditional. On one side, the robot, digitally programmed to repeat a movement in space. It never becomes exhausted by its labour, but it relies on the exhaustible energy resources that power it. On the other side, is the cob. Made most often from the land on which it is built, cob structures are unbaked earth. It requires the labour of humans, or other animals, to combine the mix. Like other earth building processes, a successful build relies on dry, warmish weather and is therefore a seasonal practice that has been carried out by humans for thousands of years. But as the two images suggest, these processes are not cleanly divided. The builder described the ancient clay cob mix as a “smart material”, a definition more usually applied to recently designed new materials, while the high-tech clay dispensing robot had to be carefully observed and assisted by human hand. One of the similarities of these two methods is their laboriousness. The robot cannot manage alone. Instead, it must be watched, restarted, and corrected if necessary. It is unforgiving, inflexible. The cob must be carefully mixed and applied, and because it retains its organic behaviour it too must be watched and attended to throughout its lifetime. These are high-maintenance processes, with very limited production – neither has been able to produce structures with the speed or scale of brick building.

As an artist, my role is this project has been to invite the contribution of different clay makers and experts and to investigate the geological and cultural significance of this material. In spite of our interest in the composition of clay as a natural material, we began with a focus entirely on human practices carried out predominately within the workshop and studio. However, as the project has developed, my interest has expanded beyond the workshop to consider other making processes that surround and inhabit this site: the making processes of other animals. I would argue that by expanding our understanding
of clay practices beyond the human we both broaden the imaginative potential of the project, and crucially begin to consider human making as only part of a broad ecology of organisms forming and reforming their environment.

To return to my two images of the robot and the cob builder, there is a third maker in the story that may offer another angle of investigation: the swallow building its nest (Figure 3). The workshop at Grymsdyke Farm is surrounded by the remains of swallows’ nests under the eaves, where they return to every summer from their winter home in South Africa.

To construct their nests, male and female swallows will collect mud in small pellets from the surrounding area, which they mix with grasses and horsehair. The mix is very specific to each swallow species. For example, even if they are nesting in the same environment, a cliff swallow will mix together a sandy consistency, while the barn swallow prefers a more silt heavy mixture.

The nests are built of around 1500 mud pellets – tiny balls of wet soil. This is a vague term, because its composition differs depending on the geological history of an area. It is also given different names depending on the size of the soil particle. Clay is simply any particle of soil smaller than 0.002mm in diameter. If the particles are larger than this, it is defined as silt, then sand, then gravel and so on up to larger boulders. How these different sized particles are combined dictates the properties of the mixture. Clay plays a specific role in that it forms a bridge between larger particles of sand and silt, and therefore provides the basis of the adhesive quality we associate with mud on a larger scale.

Swallows begin building their nest by applying a three-inch curved shelf of mud pellets on to a sheltered wall. For the purposes of nest building, the suction-like action of the clay in the mud will stick together the different particles, but as the birds are building on a vertical wall they need a very strong adhesive for their nest. This is provided by their saliva, which mixed in with the mud creates a sticky bond with the wall, and between the mud pellets.

The swallows now face the same two problems as the human clay makers inside the workshop. The first is: How to make clay structures that don’t collapse under their own weight. All three makers have arrived at the same answer to this – they take breaks, pausing after a few layers to allow the clay to dry and the water to evaporate. In a swallow’s nest the different layers are clearly visible – a physical record of the moments when the swallow took a break in building. So, it seems that for all the makers, ‘stopping’ making at regular intervals is vital to the process of making.

The second problem is how to make a strong clay structure without cracks developing. These appear when there is different moisture content in the clays being joined, or when there are air pockets. The answer is agitation, which will moisten the clay and help it to bind. A cob builder does this by treading on the clay mix. The swallow achieves this by vibrating its head quickly as it applies each pellet. This action both softens the pellets that have already been joined to the nest, and creates a watery clay slip that flows into any crevices and fills the air pockets to create a strong structure.

Although we had explored combining clay with grasses to create cob, we hadn’t tried combining it with saliva to create a strong bond, so I decided to try imitating the making processes of the swallow (Figure 4).

Faced with a ball of clay, I bit off a pellet, chewed it and rolled it around with my tongue.
Human mouths, I found, are not designed for building. Firstly, we have more fully developed taste buds than a bird. My body’s response to clay was that it was not edible and it should be rejected. This is a very strong urge to try and resist, and it made me shut my eyes—perhaps because in addition to the disgusting taste I was also biting off something that resembled excrement. When it came to sticking together the pellets to form a structure, my lips were flappy tools compared with a swallow’s probing beak, but my tongue was an excellent thing—able to press and mould the pellets into shape. But I couldn’t vibrate my head as quickly as the swallow. The addition of saliva to the clay, however, did create a good adhesive but at the expense of my own disgust.

The repetitive movements of the clay-dispensing robot are perhaps better suited to imitate the regular vibrating movements of a swallow’s beak, and this action might allow us to create stronger structures. What the robot can’t do, however, is use the local materials as the swallow and cob builder can. Nor can either the robot or the cob builder use the sticky adhesive of saliva. Each of these animals, materials and processes has specific capacities and limitations. However, by expanding our attention to processes beyond the human, we find building practices that might productively inform our own methods, and vitally we broaden our understanding of what it means to make in the wider ecology.
CONCLUSION

Our investigation into the sustainable potential of combining digital and traditional clay making processes has revolved around the figure of the robot: an piece of factory machinery rescued and given new life in the environment of the workshop. No longer one of many, this robot is now part of a cottage industry and as such its capacities are available to be experimented with in new ways – perhaps even used ‘wrongly’. Our understanding of sustainable practice is that it is one that is both culturally and ecologically sustainable – it makes with its environment whether inside or outside the workshop. A cottage industry-like practice allows us to look outside the modes of mass production. The robot is no longer fixed in its purpose to create cars, rather it is a tool that moves in space which can be used experimentally. Outside of industrial scale production, diverse materials, processes and tools can be combined: the arm of the robot, the feet of the cob-builder and the beak of the swallow.

REFERENCES


Raymond Williams, Keywords: A vocabulary of culture and society (London: Fourth Estate, 2014), 88.


Rebecca Reid, in discussion with the author. February 14, 2015. Clay Workshop at Grymsdyke Farm, Buckinghamshire.


RAF | A framework for symbiotic agencies in robotic – aided fabrication

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ABSTRACT

The research presented in this paper utilizes industrial robotic arms and new material technologies to model and explore a different conceptual framework for ‘robotic-aided fabrication’ based on material formation processes, collaboration, and feedback loops. Robotic-aided fabrication as a performative design process needs to develop and demonstrate itself through projects that operate at a discrete level, emphasizing the role of the different agents and prioritizing their relationships over their autonomy. It encourages a process where the robot, human and material are not simply operational entities but a related whole. In the pre-actual state of this agenda, the definition and understanding of agencies and the inventory of their relations is more relevant than their implementation. Three test scenarios are described using human designers, phase-changing materials, and a six-axis industrial robotic arm with an external sensor. The common thread running through the three scenarios is the facilitation of interaction within a digital fabrication process. The process starts with a description of the different agencies and their potentiality before any relation is formed. Once the contributions of each agent are understood they start to form relations with different degrees of autonomy. A feedback loop is introduced to create negotiation opportunities that can result in a rich and complex design process. The paper concludes with speculation on the advantages and possible limitations of semi-organic design methods through the emergence of patterns of interaction between the material, machine and designer resulting in new vistas towards how design is conceived, developed, and realised.

1. BACKGROUND

In this pivotal time when much rewriting of contemporary history is happening regarding how architecture is conceived and how it is produced (Speaks 2011),

This paper focuses on developing a framework for symbiotic agencies in robotic-aided fabrication through an analysis of the different agencies, their influence on the design process and the examination of several case studies. New digital tools, and more specifically robots, are often thought of as an extension of the designer’s hand. Through iterative feedback mechanisms and observation of the relations created between the designer and the robot, this paper speculates how a deeper collaboration that acknowledges the “potential otherness” (Picon 2004) of these tools, through a learning-by-design method, could lead to the creation of new choreographies for architectural design and fabrication.
Although industrial robotic arms have existed since at least the mid-1960s within specialist environments, it is only in the last two decades that they have started to colonise other locations. Robots and, more specifically, robotic arms, are not a black box that will change construction in the future. From the moment Gramazio and Kohler started their laboratory at the ETH in Zurich in 1995, robots in architecture have been concrete things with character, limits, and influences. If architects are going to work with robots, it is important to define the means and frameworks for collaboration, to design potential interactions and choreographies with them. Robots invite us to rethink the traditional unidirectional workflow from ‘digital design’ to ‘physical production’ that currently exists in construction and digital fabrication processes, to use them as more than just another fabrication tool.

The cultural impact of techniques is undeniable. Lewis Mumford, in his book Techniques and Civilization, clearly correlates the changes in the physical environment at the beginning of the 20th century, after the Industrial Revolution, with the changes in the mind. He rejects the idea that techniques can develop in isolation, uninfluenced by any other human desires than those from the people directly connected with their invention (Mumford 1959). The current scenario is of relatively unchanged humans interacting with robots and design technologies. Maurice Merleau-Ponty suggests that people can only incorporate instruments into their physical sensibilities through the experience of manipulating them (Merleau-Ponty 2013), as robots become more ubiquitous in architecture this scenario is likely to change. A future is foreseen where multiple agencies from human and non-human origin interact collaboratively to create better designs.

This paper starts by describing each of the agencies: robot, human, material, and their importance in the architectural process. Then it proceeds to analyse, through case studies, different interactions with varying degrees of participation from the different agents during the design and fabrication process. The exploration through the case studies is centred around the creation of physical objects inspired by an iterative feedback loop between the material, designer and a six-axis industrial robot. The pedagogical approach includes an emphasis on learning-by-design for various computing tools, and their interaction and feedback with the 6-axis industrial robot with a focus on the connections between design intent, computational logic, and physical realisation.

2. ARCHITECTURE HISTORIC DIVISION

Since the Renaissance - some consider it to have happened during the 12th Century (Lloyd Wright 1901) - architecture has seen a division between intellectual work and manual production. Leon Battista Alberti’s description of the architect in his influential treatise De Edificatoria makes a very clear distinction between design knowledge and instrumental knowledge, where the former defines the profession of the architect and the latter that of the builder (Witt 2010). For the last 500 years this method of designing and building remained unchanged (Sheil 2010). Architects designed and prepared drawings, which evolved through the engineers and other specialist analysis to end up fully detailed and costed. Buildings were built, forcing materials into form, corresponding as closely as possible to the original drawings. There were architects who disrupted this relationship, such as Jean Prouvé, Charles and Ray Eames, and designers at the Bauhaus, who brought machines to architecture, embedded with the idea of having machines in one’s atelier to test (Feringa 2015). These visionary architects reinforced the idea that while architects are not builders, they cannot remain isolated from the problem of building. They pioneered efforts in rethinking the relationship between design and making in architecture. Computers gave architects a new tool for the study and creation of form. They introduced the ability to create and manage greater complexity than that which could be managed
Virtual models allowed new freedoms, but some of these forms could only be pursued at great expense. Robots introduce a new technological possibility to architecture, a displacement that provides a new frame of reference, new expectations, and new consciousness. This new potential is not only about technology but more importantly about changing the relationship between thinking and doing (Speaks 2011). It shifts the production conditions towards making manufacturing a continuation of the design process.

Jean Baudrillard asked: “How can automation be smart if it makes us simple spectators?” (Baudrillard 2005). Similarly, the French painter Villemard in 1910 depicted the construction site of the future as one where the architect is seated outside pressing buttons while the machines are building a brick wall (figure 1). Research and experimentation in digital fabrication seems to be approaching that scenario, moving the architect into the role of a mere spectator, an outsider button-presser. Hence, there is a need to develop a framework for robotic-aided fabrication that allows us to redefine the role of the architect in a world where computers consistently conduct higher levels of optimisation and machines are constantly capable of higher levels of complexity in materials and construction (Greyshed 2014). In particular we need a framework that allows the robot, in collaboration with the designer and the material, to create a difference that is meaningful. The proposed framework for robotic-aided fabrication includes various steps: the architect first designs and brackets the realm of possibilities of the material through digital and physical simulations. Later, during the deployment process, the design and material are continuously analysed, using 3D scanning and robotic vision technologies, informing each other through an interactive human-robot symbiotic process that brings design and making closer, thus rendering this division obsolete.
3. SYMBIOTIC PARTNERSHIP

A human-robot symbiosis is different from the human-robot systems currently permeating architecture research laboratories and schools (Gramazio et al. 2014; Picon 2004; Gramazio & Kohler 2008). Creating this kind of interaction requires a creative design approach that takes into account the designer’s needs, material criteria, and machine possibilities, especially as it involves appropriating a machine that has neither been developed nor optimised for use in architectural tasks.

Traditional symbiotic partnerships between human and machine, as laid out by J.C.R. Licklider in 1960, involve “men setting the goals, formulating the hypothesis, determining the criteria and performing the evaluations, while the machine does the routinizable work to prepare the way for insights and decisions” (Licklider J.C.R. 1960). He already anticipated that through these symbiotic partnerships man would be able to perform intellectual operations more efficiently than alone.

During the 1960s with the advent of computational systems, ideas emerged in architecture regarding how these new methods could allow architects to give some control over the design to the end-users, allowing them to shape their living environments (Vardouli 2013). These ideas were reflected especially in the works of French architect Yona Friedman and the Architecture Machine Group at the MIT. They raised questions about authorship and performance: who performs the design? After an initial era of robotic experimentation in architecture, architects have gained a better understanding of the machine and material processes such that similar questions regarding the machine and its implications for the design model can be asked. In this case, it is not for a non-expert-centred model, as in the 1960s, but for one that redefines the roles and skills of experts in a design process wherein robots can overcome being used only as new building machines and become agents in a participatory fabrication process.

4. DEFINING THE ROBOT

There are many kinds of robots with great potential uses in architecture. For the context of this paper, “robot” refers to a six-axis industrial robotic arm. Industrial robotic arms
have been in use in the industry since the 1960s. They are a proven, robust, off-the-shelf platform that is flexible enough to accommodate the needs of the designer (Braumann & Brell-Çokcan 2012). Robots differ from other numerically controlled machines such as CNC-millers and CNC-cutters that are digitally controlled versions of well-established processes. Robots are generic pieces of hardware (Menges & Beesley 2014) and only become specific through custom-designed and built end-effectors. In this scenario, the designer does not need to concentrate on the design of the robot but on the design of the end-effector or tool that the robot will use and, more importantly, can focus on the design of the process.

The main human-machine interface for robotic arms is the teach pendant. Through the teach pendant it is possible to: control the rotation and position of each of the joints, control the position and movement of the end effector, control the robot’s movement and speed, and create programs. The pendant cannot be operated intuitively and the proprietary language of different robotic arms limits their user-friendliness (Lin & Lin 2014). Technological developments have allowed for sensors to be implemented as an alternative method to control the robotic arm through body movements. Although this allows for more intuitive forms of control, it can only be used for simple movements. Robots are not smart tools; they rely on offline programming sequences and will only do whatever they are programmed to do. Through the addition of sensors, 3D scanning technology and cameras we can equip them to become aware of their surroundings and react to certain conditions. These technologies can enhance the link between the digital data, the designer’s intentions, and the material behaviour. At this stage, robots are not able to make decisions by themselves in settings like construction sites or in the design process. The development of a real human-robot partnership becomes crucial, as humans are better equipped to make judgement calls while robots can consider the whole picture and carry out analysis.

5. AGENTS

There are various definitions of agency and what an agent is. However, the preferred definition for this paper is that from Michael Callon and Bruno Latour who define an agent as “any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own” (Callon & Latour 1981). A description of the different agencies and their potentiality is presented before any relationship is formed.

5.1 Robotic Agency

Designing and using robotic agency rather than using the robot as just another fabrication tool requires an introduction of scientific rigour to the design process; a holistic approach to architectural design that considers adaptivity; a set of organisational principles, material, and machinic processes and a mutually formative relationship between cultural and technical aspects. This implies the introduction of a technological basis for architecture, which has remained relatively elusive when compared to other disciplines (Willmann 2015). Using a robot forces architects to think systematically about what they are doing and to mechanise the complexity of craft and other manual tasks, which are normally taken for granted.

The role of the robot in architectural processes is still ambiguous. Four scenarios are envisaged that allow for different degrees of robotic participation in the design process:

• As a slave to the designer’s wishes, as can be seen in most robotic applications in architecture today: the robot only obeys human orders;
• As an amplifier that does not simply replicate the designer’s wishes, but can elaborate upon them and contribute technical expertise towards the design intentions (Negroponte 1973); this would be a human-robot symbiosis: the robot would guide the designer’s decision making according to a complex set of local and global criteria that might have been ignored otherwise;

• As a coordinator or regulator where robots make alternative decisions in human situations, as they can have a more comprehensive perspective, using their computing ability to process large amounts of information (Lem 2014); the robots only provide advice and it is the humans who make final judgement calls: this perspective merges the computing strength of the robot and the perceptive strengths of the human;

• As a consultant, who is called upon to help even if it does not agree with the personal premise of the designer (Friedman 1980).

Robotic-aided fabrication aims for a scenario in which robots enhance human creativity by giving designers an insight into their own creation and materialisation process. The degree of agency they have in the process will be defined at the point where architecture absorbs this new connection between computational logic and material realisation.

5.2 Human Agency: The Role of the Architect

Humans are constantly immersed in a physical world. Human agency is then regarded as a subjective first-person perspective on one’s way of reacting to and acting within the world (Malafouris 2008). Professional identities in architecture are diverse and dynamic. The role of the architect has varied throughout history- from the poet master-builder that frames all other arts inside his edifice (Lloyd Wright 1901) to the virtual master being recognised and acknowledged through objects that exist only on the screen (Loukissas 2012). The boundaries of architecture are continually shifting (Schon 1984). A comprehensive, traditional definition will be that of the architect as a “generalist” who needs the capacity to deal with and negotiate amongst different specialists, consultants, and clients, and achieve enough understanding to allow the execution of a design vision. The ubiquity of computers, simulation, representational and generative software and their increased use in architectural practice has convinced an increasing number of architects to give up their position as generalists in favour of establishing islands of expertise (Schon 1984) that span the areas of coding, geometry specialists, CAD managers and BIM consultants.

Computers have become central to the architectural workflow, increasing connectivity and enabling collaborative modes of practice between architects, engineers, and specialists. Additionally, they have blurred further the already ambiguous boundaries that separate architects from engineers (Loukissas 2012), since both now use the same simulation and coding tools. As the divide becomes unclear, new common fields for negotiation and discussion are created. Digital technologies and geometric modelling further challenge traditional views of architecture as an unmediated representation of the will, knowledge, and intuition of the architect. They redefine the traditional master-apprentice relationship considered central to architectural practice and to design education (Schon 1984; Cuff 1992; Picon 2010) - a situation that is still polemical and even conflictive for some architects, who feel that seeing the computer as an intelligent tool diminishes their knowledge.

5.3 Material Agency

Material agency is a concept introduced by Lambros Malafouris in his essay, “At the potter’s wheel” in which he challenges previous anthropocentric notions of agency by defining it as follows: “If there is such thing as human agency, then there is material agency; there is no way human and material agency can be disentangled” (Malafouris 2008). He goes on
further to describe material agency as something not inherent in the material itself, but as a relational, emergent property that develops through engagement with the material, as can commonly be seen in craft processes, and one that is characterised by continuous dances of agency, resulting from the coupling of mind and matter.

The concept of material agency has recently entered the architectural discourse (Picon 2004; Gramazio & Kohler 2008). Alberti once said, “It is quite possible to project whole forms in the mind without recourse to the material” (Alberti 1988). In architectural practice, materials have traditionally been used to construct a built version of an idea that was determined in advance. Designs after conception are subjected to complex processes of rationalisation where tension occurs between the material and the form due to the initial disassociation between them. Additionally, designs usually follow their initial path, disregarding any information that the material might have been trying to add during the formation process. This has resulted in a linear, unidirectional flow of information from design model to code to robot. (Bechthold 2010)

New developments in 3D scanning technology such as Kinect and cloud scanning applications [e.g., Autodesk 123D Catch] have made movement between the digital and the physical easier. These applications allow the analysis and simulation, and experimentation with material properties, and of new material configurations to be better and faster than ever before. By giving us a deeper understanding of material behaviour, they allow craft as an approach to making rather than as a specific way of making (Sennet 2009) to become an active agent during the design and materialisation process. In this context, craft and material agency refers to form being developed following the potentials of the material rather than it being conceived by the architect and then imposed on passive matter (Protevi 2005).

6. SHIFTING THE AGENCY MODEL

The use of novel digital technologies in architecture represents a challenge to the traditionally accepted divide between “two cultures” (Snow 2012) or two ways of thinking: the qualitative culture generally dominant in the arts and humanities, and the quantitative culture usually related with science and technology. The architect needs to start from an understanding of design and making, negotiating and merging them into a holistic process in which the division between the one and the other is no longer visible. This leads to the creation of an architectural process that regards robotic technology not only as another production medium but also as its cultural interface (Willmann 2015).

Understanding the implications of robotics in architecture requires a broad view of how they affect the system and its relationships. It requires integrating the parameters and principles of the robot with the material intelligence and human agency on site. Robotic fabrication allows the designer to get “closer to the analogue and material world by mastery of the digital world” (Sheil 2012) through an iterative process between the two worlds. It establishes a new paradigm in which a deep crucial relationship between architecture, technology, and its physical materiality is enabled by new modes of machinic thought. The architect becomes a designer of processes and interfaces between the virtual and the physical, and an editor of constraints for their interactions. The robot becomes the coordinator that can oversee the whole project, guiding the process of formation, in which the architect makes the final judgement calls.

Matter and material behaviour are implicated in the geometry itself (Reiser 2006). The architect brackets the realm of possibilities by embedding design principles in the
material and using constraints that open new possibilities during the formation process. 3D-scanning technologies and robotic vision then capture the complexity of these phenomena and present them to the architect and the computer to analyse before the next move. This process differs from cybernetic attempts in the early 1960s that were very open-ended towards the user input. Here the machine has a defined human goal that it is trying to achieve.

As the new architectural process finds its place, the other agencies involved in the building process will adapt. Architects will have to find which sphere they can occupy in this new ecosystem of tasks and agencies. In the current state of robotic-aided fabrication, architects are conducting material research, robotic research, geometric design, and are also designing their interactions. This situation will not continue indefinitely. Engineers, contractors, builders, and consultants will also have to find their roles and the robotic process will need new expert roles to be created. Architects will need to reframe their work and skills around these new agencies and negotiate this technological moment, which is changing the human-machine-material relationships. Similar to the revolution initiated by computers when introduced to architectural practice, the profession has largely never looked back (Cecchi 2015). The new machine suggests now as it did then: “a new range of forms, new ways of knowing and new kinds of professionals in architecture” (Loukissas 2012). Robots are changing the discipline, redefining its relationships and boundaries, similar to other disciplines like physics; the first experimenters struggle to position themselves within the established categories until eventually altering them (Galison 1997).

“Strange Strangers” is how Timothy Morton describes the relationships between entities. He says that the information at the moment of interaction between agents is always incomplete, suggesting that the outcome will always be unexpected (Morton 2012). Designers like to design, to be in control of all aspects of their creations. A shift in the agency model encouraged by new digital technologies requires the designer to relinquish some of his unidirectional control, and allow the unknown control of matter to develop during the process of becoming (Pickering 2011). This process raises questions of authorship. A new mode of non-authorship should arise similar to that of Gothic cathedrals, where the interaction between the agents was paramount. Novel hybrid-agency models, in which the architect becomes and active agent through the materialisation process and diverse agents have equal influence on the final design will be required (Carpo 2011).

7. CASE STUDIES

The following three case studies have been selected to illustrate a range of design interactions that the authors organized and investigated between human and industrial robots during the design process. The interaction in each case is positioned on different parts along the design-fabrication continuum, offering an opportunity to study and speculate on different approaches to human-robot symbiosis in architectural practice. The case studies were setup in a way that allows for identifying the potential productive connections between materials, machines, code, and humans. The role of the architect throughout the different case studies is that of an active designer of the system and of the rules for the other actors to operate upon. As an active designer, he brackets the possibilities of the system through the different stages based on an analysis of the behaviours of the other agencies. The last two case studies address material variation as a creative force (DeLanda 2004) that allows us to incorporate difference and feedback during the fabrication stage. By studying them, we can identify the skills and toolboxes that define the new role of the architect as an active agent during the design and fabrication stages.
Figure 3 Catalogues of generative design patterns from particle system behaviours and their parameters
7.1 Instructing Machines
A three-week workshop was taught in collaboration with Shajay Bhooshan, Vishu Bhooshan and David Reeves at the Architectural Association Design Research Laboratory M.Arch (AADRL), London, UK.

The case study “Instructing Machines” was run in November 2015 with AADRL graduate students. The focus of the workshop was to introduce code as a generative tool to instruct machines such as the computer and the robot and to analyse their output. It started with an introduction to the C++ language as a generative tool for designing patterns based on attraction-repulsion particle behaviours. After experimenting with this, the next step was choreographing the robot behaviour with the geometric moves by generating the G-Code from this same platform. Students worked in teams and the workflow included: generating the particle system, understanding the parameters and behaviours of particle forces, learning the constraints of the robot, incorporating them into the generative code, and finally converting the result into a set of points which could be followed in the physical world by an industrial robot. Students had the option of using the robot for either drawing or stippling their set of points onto paper. A Nachi MZ-07 6-axis industrial robot with a 7kg payload was used.

One of the initial facts that became evident when students were introduced to a robot arm for the first time was that, contrary to other machines that have a defined use, a robot arm cannot do anything without designing its tool or end effector. Students had been told to use it for drawing or stippling, so the first task was to design a tool that could handle a marker or a needle. Secondly, given the number of tasks that a robot arm can perform, its movements can be optimised in multiple ways. Its inverse-kinematic system can reach the same point in many possible configurations; some of them can be better for speed, for load, for torque, etc. For some points there can be multiple, nearly infinite, numbers of
solutions. There is also the possibility of zero solutions if the point is out of the workspace or at an impossible angle for the end effector. Without a defined tool, a single optimisation procedure and the possibility of multiple solutions for the same task, the designer is forced to think about the steps and the final result that he wants to accomplish in order to decide how to plan its motion, generate the code, and optimise its output.

The Nachi robotic arm, unlike other robot brands, compiles its code directly in the software and not in the controller so a live link can be established. This means that changes to the robotic path can be made directly from the computer. The pre-developed design program that the students were using combined the generation of the particle simulations and the generation of the G-Code for the robot inside the same software platform. This meant that changes to the attraction and repulsion forces of the particle system, and hence to the drawing pattern became immediately apparent as changes to the robot movement trajectories. This direct relationship between pattern generation and the robot’s movement meant that the design and its physical representation were directly connected. The designer becomes an editor of the generative parameters of the system, as set out at the beginning, and hence of the output, without directly designing the final product, but by controlling the digital and physical parameters for its generation.

During the process of converting the pattern to a set of points that could be used by the robot and that represent the designer’s intentions, a set of additional parameters had to be introduced to the code such as: Z-values for the robot to lift after each point or at the end of the lines so they are not continuous and indistinguishable, checking reachability to all the points, height and rotations of the designed end effector, analysis of the number of points in the digital pattern versus the necessary ones in the physical world to optimise machining time, speed of the robot, and more. The students were able to achieve this via intensive collaborative working in the studio that allowed rapid generation of patterns, immediate access to the robot for testing, and continuous access to manual jogging of the robot to understand its behaviour with regular tutor support. During the 5-day production phase of the workshop, 14 students generated over 30 physical drawings in a continuous evolution of forms. The final outcome allowed students to explore forms of design and creation using an industrial robotic arm, to understand the potentials of the machine and to realize that a series of parameters has to be considered from the early stages to have a successful, strong, direct connection between design parameters and physical output.
Figure 7 Setup for Robotic drawing of the generated patterns.

Figure 8 Photographs of robotic drawings from generative patterns.

Figure 9 Photographs of stippled robotic drawings from generative patterns.

All figures from AADRL, 2015. Instructing Machines workshop.
Figure 10 Left: custom-made end-effector. Right: Generative design system based on multi-agent behaviour.

Figure 11 Left: Initial path setup. Right: Extrusion detail.

Figure 12 3D scanning using Kinect for robotic path recalculation and for calibration between physical and digital models.

Figure 13 Left: re-computed tool paths based on deposited material. Right: Built prototype of spatially extruded polymorph plastic. 1.8m tall. All Figures from Team MRVL, Studio Bhooshan, AADRL 2015.
7.2 MRVL Plastic Spatial Printing:
A collaboration with Studio Bhooshan from the Architectural Association, Design Research Laboratory, M.Arch (AADRL), London, UK.

MRVL is a team of 4 students from Studio Bhooshan at the AADRL. In December 2015 during the final stages of their 16-month Masters program, they worked with the first author as an observer and robot consultant to their fabrication process. The focus of the design lab is in developing prototypical construction methods that allow describing, evaluating, and searching for the right designs using robotic industrial arms (Architectural Association 2015). The team designed and developed a custom-made end effector for a 6-axis industrial robot to spatially extrude polymorph plastic in a collaborative fabrication process. Polymorph plastic traditionally comes in granules that look like small beads.

The team developed a design system based on topology optimisation and multi-agent generative design principles. The system, following the rules established by the designer, generates different configurations of architectural space, providing the positions of main and secondary structural members. These are then transformed into paths for the robot to extrude / deposit plastic. The purpose-built end-effector heats the pellets to 90 degrees before starting extrusion and has sensor controls to prevent overheating.

The specific characteristics of the material make it shrink slightly after extrusion. This, combined with the precision of the robotic arm, which cannot adjust on its own to the varying shrinkage, necessitates the introduction of a robotic vision system in which each path is scanned after deposition. Information obtained from the 3D scan is then fed back to the original design model in order to calibrate the digital and the physical, analyse the geometry, and re-compute the next extrusion path to ensure that all structural members are connected with each other. A system in which the robot becomes an agent responding to previously extruded plastic is created.

The process requires extremely active participation on the part of the designer during the fabrication stage. As opposed to traditional robotic fabrication processes, in which all the instructions are sent to the robot at the beginning, the setup feedback loop requires the robot to ask the designer after each path where to go next. For each path, the robot needs to keep the form-optimisation while avoiding already deposited material. As the form builds up, it becomes more densified, so the robot’s awareness of its environment is crucial. A semi-autonomous system is created, in which the robot can keep to the next path as per its analysis based on the scanned information and re-computation of the system, or the designer can provide a different solution based on his or her qualitative analysis and overall design intent. As the design adapts to the environment and responds to previously extruded plastic, it is continuously changing during the fabrication process. The final outcome can have several degrees of variation from the initial input, hence the importance of the designer’s active presence during the process to control variation and adapt both the digital model and the physical model through the robot. During the 4-day production phase at the Welsh School of Architecture, the team built a 1.8-meter-tall prototype with a weight of 25kg. The robot printing time was 12 hours.

7.3 Pop-Up Concrete:
On-going research project developed by the author at the Welsh School of Architecture.

Flat packed, pop-up concrete structures are explored as a means to create a flexible and adaptable fabrication system for the creation of thin-shell, medium-span complex concrete
structures, furniture, and complex leave-in formwork for larger structures. For this process, Concrete Canvas, a new material technology, is explored due to its hybrid characteristics that blend fabric and thin-shell tectonics. The focus of the research is to develop novel construction systems that integrate with the current robotic and architectural discourse. The digital workflow includes: pattern design; digital simulation; on-site cutting and inflation through a collaborative, iterative, material feedback loop; structural analysis; and hydration of the final shape. It allows the designer to manipulate concrete structures on-site, as informed by structural analysis, designer input, and their own choices.

The popped-up geometries are based on a parametric system of 2D cutting patterns performed in ‘concrete canvas’. The 2D patterns transform into extended 3D surfaces by lateral buckling induced by spatially non-uniform growth during the phase-changing period of the material. The system setup is initially done both physically and digitally, so that when the units pop up they inform and calibrate each other through an iterative feedback loop. A pattern gets embedded in the material so that, when it pops up, it is capable of a range of configurations that are structurally stable while also achieving qualitative architectural effects. Fabrication, in this system, comes from embedding transformative capacities in the material, rather than from transferring the form directly from the computer into the material as in traditional unidirectional fabrication processes.

Beyond the optimization criteria and parametric setup, the system focuses on collaborative design as a way to approach material exploration through robots. Typically, the outcomes of a fabrication process are predetermined. However, the introduction of a 2D cutting
pattern within a concrete phase-changing material system over a pop-up process allows for several configurations to be created through a collaborative design and fabrication process. The feedback loop between designer, material, and robotic production creates negotiation opportunities that result in a rich and complex design process with many intelligences: human, the algorithms embedded in the design, and the material.

Concrete Canvas, as a material, allows for experimenting with new uses for concrete. It is composed of a layer of dry cement with its reinforcement impregnated between two sheets of fabric. In its dry state the material can be formed and worked as malleably as fabric, but when hydrated it becomes very rigid, acquiring the stable properties of concrete. Given this duality, the behaviour of the material is probable, but not certain. This characteristic allows one to assess the structural influence of the patterns of cuts and joints and the effects of its variations during the pop-up process. The system uses inflation to pop up into a surface. Once a satisfactory shape is achieved, the concrete is hydrated, allowing it to cure and become structurally rigid.

Using new digitisation technologies, the popped up shape is scanned and taken back to the computer for structural analysis and calibration with the digital simulation and for design refinement. With this information, the designer can continue modifying the inflation until equilibrium between material, structure, and form is reached. Finally, the concrete is hydrated and left to settle for 24 hours. A feedback loop between the digital and the material is created and continuously updated during the form-finding and form-making processes. The aim of the system is to provide a production technique for the quick
Figure 19 Diagram showing the workflow set out and feedback loop.

Figure 20 Designer-robot-material negotiations during the formation, or pop-up process, of the material.

Figure 21 Left: 2D pattern and resultant 3D geometry. Middle: Concrete details. Right: Live load testing of prototype.

Figure 22 Envisioned fabrication scenario, including path planning workflow and feedback loop.
deployment of shell structures, where modelling, analysis, and fabrication are integrated. Form in this process emerges as a result of a negotiation amongst structural, material and design constraints.

The generation of pop-up structures is not random, but caused by set boundary conditions of the embedded cut and joint pattern, and follows precise physical principles during its pop-up. Through the feedback loop and with defined boundary conditions, the results can indirectly be controlled and emergent shapes can be created by stopping the process at any point in time during the pop-up phase of the concrete. 3D pop-up geometries can achieve a space-enclosing surface faster than 3D printed ones.

In this case, as opposed to that of the previous one, the designer constrains the possibilities of the system through the design of the cutting pattern and the properties of the concrete fabric. During the pop-up process, decisions can be made that favour different final configurations. This variation is bracketed to the realm of possibilities allowed by each cutting pattern initially defined and simulated by the designer. This kind of approach changes the role of the architect to that of an editor of constraints and a designer of a system through the material and the machine, rather than that of a designer of the final product.

8. DISCUSSION

The case studies show how using the symbiotic agencies of the robot, the designer and the material allows us to explore opportunities to create new aesthetic languages for our built environment. The interaction between the robot and the designer can happen at different stages of the design, from very early phases as in the first case study, up to the final delivery of the design, or during its construction as shown with the pop-up concrete and the plastic deposition examples. In these last two cases the iterative fabrication process leads to a sentient material that engages, through the robot, in a design dialogue with the architect.

Experimenting with materials as per case studies 2 and 3 proved to be an immersive and fascinating field very easy to get lost in (Hale 2013). Keeping in mind that the main objective is searching for new modes of practice and connections between the different agencies allows us to speculate ways in which architects can redefine their role while maintaining a vital connectivity to the multiple forces, acknowledging the importance of the different actors: technique, geometry, material, and machine, to their designs. This shift represents challenges for architecture that open new formal and epistemic opportunities (Witt 2010). In these envisaged scenarios, architects are no longer designing buildings and its works but rather designing performances between human and non-human entities, editing their constraints, relationships, and the environments in which they evolve through the use and invention of new machinic and non-machinic agencies that operate in the physical world.

9. CONCLUSIONS

The current status of robots in architecture is that of providing a new sense of ‘intimacy’ between the designer, his or her tools (Willmann 2015), and materials similar to those which painters and sculptors have enjoyed, yet with the precise digital control. This control is achieved through the use of sensors and vision technologies guided by the machine. The exactitude of variation during the materialisation process is new to the architectural designer. However, concrete, larger-scale industrial applications of robotics in architecture are still missing.
Robots support a new multidisciplinary approach to design, encouraging architects to work directly from early stages with engineers, materials scientists, and electric engineers providing a more holistic approach to construction. They allow architects to mix craft and tools in an intellectually meaningful way, creating a trinity of material, technology, and form (Lynn 2008). The usage of a robot, its limitations and constraints has to be considered from the beginning. This requires the incorporation of specific thinking during the generative design stages, as shown through the case studies. However, robots are only one part of the construction process, and in some cases the robotic part can further complicate downstream and upstream processes. Robotic fabrication needs to be able to handle a continuum of inputs and outputs feeding into each other. The methods in which robotic processes integrate with the rest of the construction site, and in which robot-human choreographies can be measured and adapted to the different routines needed during the on-site life of a project, are enormous areas for exploration.

These case studies demonstrate a number of proof-of-concept human-robot collaborations for robotic-aided fabrication. This design agenda involves not only human-robot interaction, but also robot-robot interaction and the development of a range of robotic and multi-robotic choreographies and their orchestration. Robotic-aided fabrication holds the potential for rethinking the role of the architect in the design and fabrications process. It allows for the creation of a new professional role for the architect that combines critical thinking whilst taking advantage of new tools and agencies interacting collaboratively to create greater designs that would be nearly impossible otherwise. In its current status, it encourages performative dances of agency without a defined centre.

REFERENCES
Books.


Speaks, M., 2011. Lecture at University of Michigan, Taubman College. Available at: https://www.youtube.com/watch?v=2lSnW0cuV6Y


Design-research by making: An educational hands-on approach to design-research through manual/robotic processes

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ABSTRACT
This paper presents educational experiences, linking analogue and digital design approaches. It suggests physical prototyping as a novel form of design research in an educational context, exploring design opportunities fostered by fabrication processes. The authors describe insights gained while leading two courses at Graz University of Technology, focussing on tactile experiments of forming materials, by hand or robots, guided by the material behaviour and reaction. Furthermore, this paper wishes to point out the advantage of research-based education, aiming for an understanding of design thinking that goes beyond curriculum and current technologies, fostering an open-ended development process.

INTRODUCTION
The unprecedented technological advances and paradigm shifts in design processes have had a strong impact in architectural practice, with a direct repercussion in education. With the rapid speed of new developments, there is an extensive discourse about the future of architectural education, with opinions converging to the belief that design education should be research-based, to keep up with current topics and technologies (Buchanan, 2001; Matthews and Buur, 2009; Simonsen et al., 2012). In the cases described in this paper, the authors combine design-research undertaken as part of their respective PhD dissertations with teaching concepts and methodologies developed during their teaching appointments at Graz University of Technology.

During the last decade, we have observed a strong tendency of linking the digital world to the physical-material realm. One the one hand, with the development of software that simulates physical behaviour, on the other hand, with the rapid development of digital fabrication techniques and interfaces, i.e. easy programming of industrial robots. In the age of digital fabrication, the role of architects in the design-to-build-process changes significantly, as they are able to extend their digital design competencies into the physical world, thereby gaining control over production and materiality. As Menges describes it “A novel convergence of computation and materialisation is about to emerge, bringing the virtual process of design and the physical realisation of architecture much closer together, more so than ever before” (Menges, 2012).
In our approach, we combine the advantages of the hands-on experience of the “Design-Studio” (Anderson, 2010) with the pedagogical approach and educational goal to provide students with special skills in design computation and fabrication, bridging design-thinking to analogue and digital making. In this “Research by Making” process, students explore morphogenetic strategies through digital and manual design experiments, with the aim to develop different kinds of sensibilities, intuitions and skills.

DESIGN RESEARCH
As constantly discussed in architecture conferences, Design Research still searches for identity and content. Groat and Wang, in their book Architectural Research Methods (Groat and Wang, 2001) tackle several of the issues regarding tools and methodologies for researchers. However, traditional structures of research do not prove effective any longer. New technologies not only affect the way we design, but they also seek for new paradigms in Design Research. Henk Borgdorff in the Debate on Research in the Arts claims that “Art practice qualifies as research if its purpose is to broaden our knowledge and understanding by conducting an original investigation in and through art objects and creative processes” and that “Research processes and outcomes are documented and disseminated in a appropriate manner to the research community and to the wider public” (Borgdorff, 2006). In that sense, there is no better research output than built examples to disseminate the results and findings of Design Research within the academia as well as to the industrial partners and local community. Design Research is a relatively young field, which suffers several “misunderstandings on the way to intellectual and practical strength” (Buchanan, 2001). Buchanan suggests that the origins of Design Research “may be traced to the early seventeenth century and the work of Galileo Galilei” and that “the creation of what Bacon calls ‘artificial things’—was generally ignored as a subject of learning, except to the extent that the design of instruments played a greater and greater role in the investigation of the natural sciences” (Buchanan, 2001). However, it was in the 1960’s that Design Research started gaining attention among several disciplines. The Conference on Design Methods at Imperial College London, in 1962, was the stepping stone that led to the founding of the Design Research Society (DRS) in 1966. Some years later, Herbert Simon paved the path for what he named the “Science of Design”, referring to “a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process” (Simon, 1996). According to Bruce Archer’s definition at the Conference of the Design Research Society in 1980 “Design Research is systematic inquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value, and meaning in man-made things and systems” (Archer, 1981). Therefore, Design Research opens up new ways of thinking about, knowing and doing design (Simonsen et al., 2012). Among the aims of the Design Research Society is to recognize “design as a creative act common to many disciplines […] to promote the study of and research into the process of designing in all its many fields […] advancing the theory and practice of design” (Aims of the Design Research Society, 1980).

Nigel Cross, renown design researcher and educator, questions Simon’s concept of “Science of Design”, which aims to improve the understanding of design through scientific methods – as opposed to that of “Design Science”, a term first used by Buckminster Fuller, which is an attempt to extract knowledge from the natural world, with the aim to use it as design input or inspiration (Margolin, 2002). Several researchers agree that Design Research may be distinguished in Research “into” Design, Research “by” Design and Research “for” Design (Cross, 2006; Frayling, 1994; Friedman, 2008). Research into Design is mainly a bibliographical approach, it mainly is the study of a design, building or object that is already finished. Research by Design might relate to material research, development work
or action research, and Research for Design means that the end product is an artefact, in the sense that “the thinking is embodied in the artefact” (Frayling, 1994).

Based on Frayling’s work, Friedman raises the problematic on Design Research, highlighting “the failure to engage in grounded theory and developing theory out of practice” (Friedman, 2008). In his paper he aims to disambiguate the practice-based research as a form of theory construction. He criticizes Frayling’s definition of Research by Design as unclear and attempts to cast more light on the subject at hand. Tacit knowledge is obviously important in design disciplines, however “tacit knowledge and reflective practice are not the basis of research and theorizing”, a framework of explicit knowledge is required (Friedman, 2008). He questions the misconception that practice qualifies as a research method and explains that “all knowledge, science and practice rely on rich cycles of knowledge management moving from tacit knowledge to explicit and back again” (Friedman, 2008). Establishing this constant feedback loop from tacit to explicit knowledge and back is also a central concept in the work presented here, both as part of our research methodology, as well as a workflow during the two seminars at Graz University of Technology.

RESEARCH BY MAKING

Simonsen describes Design Research as a process of knowing, he characterizes designing as “knowing through making or doing” (Simonsen et al., 2012). Our approach seeks to extend the paradigm of Research by Design introducing a possible methodological framework and teaching approach of Research by Making. In contemporary architecture education digital-physical experiments play a central role. Research by Making integrates materiality and physical properties in combination with computational methods and digital fabrication. The models resulting from material experimentation may be unpredictable, as they highly depend on material behaviour. However, the tacit knowledge obtained by the students is a foundation for what Donald Schön defines as the designer’s “reflection-in-action”.

Donald Schön, professor of education and planning at MIT, describes the difference between “knowing-in-action” and “reflection-in-action”:

Knowing-in-action is “…the repertoire of routinized responses that skilful practitioners bring to their practice”, gained through training or experience (Schön, 1985). “It can be seen as consisting of strategies of action understanding of phenomena, ways of framing the problematic situations encountered in day-to-day experience… It is a dynamic knowing process, rather than a static body of knowledge, in the sense that it takes the form of continuing detection and correction of error, on-line fine-tuning, all within the framework of a relatively unchanging system of understanding.” (Schön, 1985).

He expounds that if we operate outside our normal routines, outcomes are not as expected - surprises, uncertainty, or non-understanding occur. Therefore, we need to “reflect” on our actions, on the spot, so we can still have an impact on the outcome. “Our spontaneous responses to the phenomena of everyday life do not always work. Sometimes our spontaneous knowing-in-action yields unexpected outcomes and we react to the surprise by a kind of thinking what we are doing while we are doing it, a process I call reflection-in-action.”. The reflection “… has a critical function, questioning and challenging the assumptional basis of action, and a restructuring function, reshaping strategies, understanding of phenomena, and ways of framing problems.” (Schön, 1985).

During the seminars presented in this paper, the students engaged in a hands-on approach,
where their choices and “spontaneous responses” highly depended on the material at hand. An elastic material would form different geometric configurations if stretched in a certain way, whereas a manually thermoformed plastic sheet would remain malleable for a specified amount of time, changing its behaviour and subsequently the force needed to form it.

Schön’s reflection process offers a huge potential for architects to envision new ideas, solutions and theories:

“Depending on the context and the practitioner, such reflection-in-action may take the form of on-the-spot problem-solving, theory-building, or re-appreciation of the situation. When the problem at hand proves resistant to readily accessible solutions, the practitioner may rethink the approach he has been taking and invent new strategies of action. When a practitioner encounters a situation that falls outside his usual range of descriptive categories, he may surface and criticize his initial understanding and proceed to construct a new, situation-specific theory of the phenomenon.” (Schön, 1985).

Schön’s conceptual framework is linked with the philosophical writings of Gilbert Ryle (Ryle and Dennett, 2000), that distinguish between “knowing how” and “knowing that”, which is of particular importance for architecture, as we very often engage in hands-on activities, both in academia and in praxis.

While traditional education starts out from a deep study of the theory that subsequently evolves into generating design praxis, the approach of Research by Making departs from the constructionism point of view that praxis should pave the way to theory. The practical experiments help students to construct the questions that will later be answered by the theory. It is not a linear process; it could better be described as a feedback loop where experiential learning is combined with theory and practice in several iterations. As Ranulph Glanville remarks, one difference between practice and theory is that “theory is created by an observer standing outside the system to describe it, while practice necessarily involves the observer acting within the system” (Rodgers and Yee, 2014). This is directly linked to the beliefs of Michael Polanyi about “tacit knowledge”, saying that there is a different type of knowledge that cannot be put into words, the experiential knowledge usually related to creative disciplines, associated with the actual praxis. An example of this is the knowledge transfer from a Master artist to the disciple. Polanyi proclaims in his book The Tacit Dimension that “we can know more than we can tell” (Polanyi, 1966). Cash and Culley highlight the role of Experimental Studies in Design Research, as this approach supports both theory building and theory testing (Cash and Culley in Rodgers and Yee, 2014).

Research by Making relates to “constructive design research” introduced in the book Design Research through practice, where the authors define this as “design research in which construction - be it product, system, space, or media - takes center place and becomes the key means in constructing knowledge” (Koskinen et al., 2011). The above definition usually involves a prototype, and in the case of the presented projects, the prototypes are a central part of the design process. It is understood that “without this culture of doing, many things of interest to designers would go unnoticed” (Koskinen et al., 2011).

In this realm, the case studies presented in this paper aim to showcase a hands-on educational approach where students learn by doing, implementing both analogue and digital media for the exploration of architectural form.
LEARNING BY DOING

The following chapters describe two design courses, taught as seminar-series at Graz University of Technology, where educational methods of Learning by Doing are implemented. The two seminars “Analogue and Digital Form-Finding” and “Digital Fabrication” aim to showcase the Research by Making methodology and the educational benefits of this pedagogical approach.

Seminar 1: Flexible Matter: An Analogue and Digital Approach to Form-Finding
The first course introduces real-time shape exploration employing analogue and digital form-finding. The students embark on a hands-on experimentation with tensile structures resulting in design proposals for lightweight structures. The experiments involve physical form-finding, following the tradition of Frei Otto, as well as computational form-finding, simulating tensile and bending behaviour with the use of dynamic relaxation of spring-particle systems (Kangaroo plugin for Rhino). By establishing feedback between digital media and physical prototypes, the creative process is informed by the material characteristics and structural properties. The aim is to utilize the parametric model not merely as a representational tool, but as a morphogenetic tool, that embeds the physical behaviour and interaction among tension-active elements, giving rise to structurally optimized forms.

The Flexible Matter workshop at Graz University of Technology started with a set of analogue experiments on a measured plexiglass frame where elastic textile (with elasticity in both directions) was tensioned. The first set of experiments involved the form-finding of typical tensile structure primitives, such as the Hypar, Conic and Barrel Vault, together with possible combinations of the above. Thus, already from the initial design stages, the elasticity and material characteristics led to a vocabulary of possible formations within the broader category of tensile structures. This set of experiments also studied the repercussion of a 2D cutting pattern on the 3D form, understanding the translation of forces into geometry, the continuity and discontinuity of force transfer as a design gesture. A tensioned membrane, just as the soap films of Otto, tries to minimize its material (energy) to span between the given borders. The pressure is the same on both sides of the soap film, so the material system settles in a configuration with mean curvature as close to zero as possible. Each modification in the location of an anchor point or tensile force will have a direct repercussion on the form, so that all forces acting upon the model are in equilibrium. Thus, design decisions are taken by the material itself and the forces acting upon it.

A physics engine, such as Kangaroo, acts as a design decision support system; it assists architects to increase their intuitive understanding of the structural behaviour of geometrically complex forms. “The environment educates the user as to the effects of forces on the form of structures and provides an interactive form-finding” (Kilian and Ochsendorf, 2005). While traditional architecture and engineering aims at the structural optimization of an existing form, a dynamic form-finding system can lead to a real-time discovery of structural form encouraging the morphogenesis of optimized structures.

Considering a pedagogical approach of Learning by Doing, the students investigated known architectural case studies by making models, understanding the morphogenetic principles that govern the construction. This was not an exercise about copying the external form, it was rather an exercise about understanding the principles that generate the form. A hands-on approach encourages tacit knowledge, which combined with the theoretical background, leads to more informed decisions. As Koskinen explains, a design process “may start from theories, methods, and fieldwork findings, and just as often it
begins with playing with materials, technology, and design precedents” (Koskinen et al., 2011). With this attitude in mind, the workshop’s experimentation departed from the study of built examples to further evolve into original design ideas. The built examples that were used as case studies were drawn from various different periods of architectural history, thus ranging from the Institute of Lightweight Structures (ILEK) to the Paradise Pavilion by Chris Bosse.

Extracting the underlying generative logic of the analogue experiments and understanding the forces in play is the first step towards building a digital setup that simulates the physical behaviour. For solving similar problems, Dynamic Relaxation of spring-particle systems has been used for over three decades in the engineering world (Day, 1965). However, the recent integration of visual algorithms such as Kangaroo Physics in Grasshopper (Piker, 2013) has resulted in a very user-friendly and intuitive tool in the hands of architects.

In an attempt to mimic the physical behaviour of a material system, we translate physical properties into mathematical equations that generate the geometry in the computational environment. Thus, an elastic textile can be represented by a spring-particle system, translating mesh vertices to particles and mesh edges to springs, in other words a system of points and lines. The Kangaroo physics engine computes forces, velocity and lengths of springs that behave according to Hooke’s Law. Having obtained an understanding of the forces acting upon the models, the students were able to build their own Grasshopper definitions, compare the results to the physical models and rectify any of the two. In several cases, the form-finding experiments revealed some unpredictable results that emerged from the self-organizational capacity of the system to regulate and distribute forces to reach equilibrium. As Piker explains “one great advantage of physically based methods is that we have a natural feel for them, and this intuitive quality lends itself well to the design process […] through the application of real-world physics we can make computational tools that really work with us to design in a way that is both creative and practical” (Piker, 2013).

Students had the chance to get their “hands dirty” and acquire experiential knowledge about tensile structures. The process involved less thinking and more making, the students faced problems and developed strategies to solve them. Aware of the potential of the material system at hand in a conscious and intuitive level, they were liberated from the restrictions of the tools and motivated to pursue their design ideas.

During the development of the projects, students implemented analogue and digital media in parallel. There was a conceptual feedback across media, which aided students to take
informed design decisions. It is important to clarify that we are not looking at analogue-digital processes as two competing strategies, but as complementary tools that provide different type of input yet interrelated with each other. Analogue tools proved more efficient with handling qualitative characteristics of the design, transmitting the atmosphere of the architecture, understanding empirically the forces acting upon the structure, dealing with issues of assembly, and detailing (Symeonidou, 2015). In contrast, digital tools can handle huge amounts of data, making them appropriate for handling quantitative characteristics of the design. They allow quick changes but they require certain experience with real-world physical forces, so that the user can calibrate the values for drag, spring force and edge conditions.

In particular, the use of prototypes in early design stages conveys a lot of embedded design information. However, as Stappers explains, “the value of prototypes as carriers of knowledge can be implicit or hidden. They embody solutions, but the problems they solve may not be recognized” (Stappers, 2007). Therefore, they represent great design tools for an exploratory phase of design ideation.

The aim of the workshop was to intrinsically involve analogue and digital design processes, not as separate routines, but as an integrated design approach, where the two media counter-inform each other from the very beginning of the design lifecycle.

Understanding the association between geometry and material behaviour, the elastic properties of membranes or computational spring meshes and the obtained form, leads to a “synergetic approach to design integrating form, structure, material and environment” (Oxman and Rosenberg, 2007).
The presented projects show an overview of the techniques and methodologies investigated during the Flexible Matter workshop that took place at Graz University of Technology. It addresses issues of design research through praxis, and design processes that encourage creative design thinking towards an integral approach in architecture, which integrates material behaviour, functionality, material economy, aesthetics and optimized structural performance.

In the second course, manual production of prototypes is combined with digital fabrication, working in the interdisciplinary field between design, craft and robotics. It investigates open design experiments, where form arises in a dynamic interplay between the operator/designer, the material and the robot. In an experimental set-up, students explore possible shapes and design outcomes by thermoforming flat sheets into 3-dimensional objects - manually or robotically. The course is project-based, allowing students to learn by experiencing and making their own discoveries, giving them a starting point and guidelines, combined with skill building sessions.

Architectural education is traditionally often based on “Making” - this contemporary approach combines manual, digital, and material aspects. As the role of the architect changes in the design-to-build chain with the increasing use of digital fabrication, this paradigm shift has to be addressed in education. Our relation to materiality changes, offering possibilities to have bigger control over the fabrication phase and integrating these aspects in the early design-phase. The course examines the potential that arises, when production tools - manual or machinic - are used as key part of the design process, which a special benefit of linking these two ways of “Making” by digital tools, i.e. a motion capture system.

Within the realm of digital fabrication, robotic technology plays a special role, because of its leeway for customization. Gramazio and Kohler, pioneers in the use of robots in architecture at ETH Zurich, write about it: A robot “… has not been optimized for one single task but is suitable for a wide spectrum of applications. Rather than being forced to operate within the predefined parameters of a specialized machine, we are able to design the actual “manual skills” of the generic robot ourselves.” (Gramazio and Kohler 2008). The approach employed in the presented seminar uses this special advantage of a robot: to work with customized end-effectors. Thus, the same operation that is done manually can be replicated by a robot. By using the same experimental set-up for hand and robotic forming, both processes are relatable and comparable.

At the beginning of the seminar, each student (our student group) is equipped with a set of materials and tools: a number of plastic panels, a frame to hold the panel, a set of geometry tools to form the surface (“deformer”), and a heat gun. The panels are shaped by manual and subsequently by robotic movement, in conjunction with a local, form-giving counterpart. By complex movement operations like push, tilt, twist, and shear, planar materials are transformed into customized elements. The final geometry is not pre-defined (in the digital realm) before materialization - it emerges during the actual production process. A result is anticipated, but the expectations are not always fulfilled: surprises and discoveries happen, as well as accidents.
Alternating with the “Making”, the participants receive lectures and tutorials, about manual techniques and digital tools. Furthermore, they are introduced to the fabrication machines employed in the course - a laser cutter and a 6-axis industrial robotic arm - as well as to the motion capture system installed in the school lab. The actual contact with the equipment is vital for the skill building and acquiring of tacit knowledge previously discussed. Experimenting with a range of new tools, the students develop curiosity and learn by doing, getting directly involved in the design process by making.

By means of hand-forming of the panels, the participants are introduced to the material and forming behaviour of plastics (acrylic glass, polystyrene, PET) when exposed to different temperatures. Thereby, possible shapes and design outcomes are explored. These hands-on experiments are crucial for building up a design intuition, which further informs the digital process. As Bechthold and King describe it, “…physical and digital experiments produce many ideas in rapid sequence. Rough prototypes, even those produced manually, provide early feedback on opportunities, but also help failures to emerge quickly. The evaluation criteria derived through the analysis are used to filter out ideas for further development…” (Bechthold and King 2014). The students benefit immensely by starting directly with a hands-on-approach, gaining knowledge about forming, timing and distance of heating. After producing their first test models, students are able to evaluate and select the most successful experiments and continue with a clearer design intent. One of the main research-achievements in this seminar is the understanding of the relation between manual and robotic forming. This is accomplished by capturing the hand-forming process with a motion tracking system. Using camera-based technology, the most successful hand-forming outcomes are recorded. The students “choreograph” scenarios, which they develop in the manual forming test. The movement and speed of the crafted processes are recorded and translated to robotic operations.

Different ways of translating the tracking data to the robot are used: from direct translation, over picking one pattern and replicating it, to altering and optimizing the
manual process. The students make use of several different software packages and plugins, including Rhinoceros, Grasshopper and HAL, a Grasshopper plugin for industrial robots programming. This enables them to programme the robot easily, and adjust processes simply by moving sliders.

The outcomes of the experimental case-studies offer a great insight on the relation between craft and machine, as well as on their respective advantages and disadvantages. The biggest advantage of hand-forming is the quick start and the freedom of operations that can be performed by hand. Manual forming may induce some imprecision in the heating area and the forming movement by hand. This is seen as an exploratory phase that can be further refined with the use of digital media. Through this iterative workflow, students exploit the advantages of digital and robotic technology: to adjust processes parametrically, to precisely replicate successful prototypes, or to create parametric variations of a module. In this approach, intuition, manual skills, material properties and machine processes are linked in a dynamic interplay. Reflection is taken on the produced prototypes, drawing conclusions on the design potential for similar materials and design processes.

CONCLUSIONS
In the studio-based courses described above, form is the result of manual or robotic gestures of stretching, bending, heat forming. De Landa would describe such a process as an “analogue search algorithm”. We refer to physical experiments as “analogue computation” because the material “computes” its form - it self-organizes for a given set of boundaries, forces, temperature or other constraints. Having understood the modus operandi of Research by Design, we combine new technics and methodologies, taking a step further into Research by Making as a method of architectural inquiry. One of its main benefits is to foster intuition, knowledge and “reflection-in-action”. Linking digital and manual fabrication allows for building up new sensibilities by experiencing and making. This digitally extended Design by Making workflow fosters a new way of thinking about architectural design and practice, based on exploration of materiality. Other than in typical prototyping, the result is not simulated before production, providing an open field for experimentation. If properly employed, this methodology can unlock creativity and the discovery of new aesthetics and formal languages. Engaging research-based education as we understand it, students are able to gain skills in cutting-edge topics of the architectural discourse. In a pedagogical point of view, they are encouraged to be curious, willing to take risks, move out of their comfort zone and operate in a field of uncertainty. A Research by Making approach challenges students to expand their skills and design-thinking methodologies. They acquire new knowledge, both tacit and explicit, are able to construct their own theory and test the concepts they previously learnt in architecture school by actually building small-scale prototypes.
The role of model making in architectural education is well established in the academic curriculum, and digital media have brought a new dimension to traditional model making (Stavric et al., 2013). Brett Steele alludes to the common belief that “architecture is only ever learned by getting your hands dirty” (Self and Walker, 2010). He explains that this is done through the construction of physical prototypes, 1:1 models, whose “working difficulties and eventual results offer the designers vital insight and understanding into how they take a next tentative step forward”. The technological developments in CAD/CAM may have achieved a seamless transfer of information from designing to making, a file-to-factory continuum from the computer screen to the CNC machine. However, as we observed, the creative process itself is not so easy to trace, very often thoughts are fragmented, discontinuous, yet creative, jumping from one idea to another, taking one informed decision, followed by a random or controversial design gesture. In the same fashion, a designer implements different media during the design process.

In the framework of the student seminars presented in this paper, the challenge was to adopt an integral approach to design, informed by material properties. The aim was to address computation in its multiplicity negotiating material, structure, design and function. This scheme enabled us to go beyond the established morphological vocabulary into more experimental and non-standard geometries, as well as to employ and assess a novel attitude towards design teaching, introducing cutting-edge technology through experiential learning.

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REFERENCES
Design methods: deep agencies for spatial production

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“Methodological straight-jackets can only suppress the emergence of new ideas. Theoretical imperialism is stifling... many people repeat these principles most piously, even turning them into some kind of orthodoxy; very few actually come up with new ideas by putting them into practice.” Introduction to Detachement (by Michel Serres), René Girard

Design Methods: Deep Agencies for Spatial Production argues for increased exposure, critical positioning, and acupuncture-like use of design method in the design studio. Three primary points regarding the agency of design methods are leveraged and positioned: (i) the virtues of increased design versatility; (ii) the production of innovative form; and (iii) the construction of disciplinary knowledge. Fourteen design methods are identified, select design methods are drawn out and thickened (i.e., articulating the definition, etymology, preferences, author relations, (in)directness to architecture, template for operations, and case studies) and four specific design method frameworks are supplemented by design examples.

INTRODUCTION

Increasingly, a primary challenge facing the architecture design studio is the lack of understanding that a discipline for design must be established - specifically in relation to effectively implementing design methods when designing architecture. Operating in the margins of current architectural debates, the critical location of design methods and their respective affordances has been relegated to the blind spots of spatial production - suppressed by more dominant pedagogical agendas. As educators, we must recognize and address this crucial aspect of spatial education if architecture is to remain vital in augmenting the cultural imagination.

Given the changing nature of political, geographical, and cultural spacescapes, these thoughts suggest that we frame, position, and embrace multiple means for making work - augmenting ossified and limited understandings of methods for design. Flows of capital, global interconnectedness, and technological advances are challenging static, and perhaps outmoded notions of architecture. This suggests that we raise our individual and collective awareness of diverse design methods to negotiate the surge of changes: increasing our design dexterity and versatility to optimize the capacities of spatial realms; to advance innovative form - when appropriate; and to contribute to the continuous development and transformation of disciplinary knowledge.
FRAMING

For the sake of making a point, I suggest, exaggeratedly, that many architects - including this one, are spatially myopic. This myopia mutes architecture’s real agency, imaginative potential and cultural durability. Causally linked to a reliance on categorical and typological fixity, totalizing approaches and homogeneous project ideas, our individual and collective spatial imaginations are fatigued, further draining the generative cultural and practiced capacities of architecture. Post-Enlightenment byproducts, including systematization, a reliance on empirical knowledge, architectural autonomy, and pragmatic domination, contribute to this atrophied sense of spatial wonderment.

Recently, architecture and schools of architecture have been driven by problem-solving approaches; the ever-present weight of the program - the default and uncritical ghosts of functionalism lurking; formal techniques; and the here today, gone tomorrow fashion regime. Articulated through myriad vocabularies of modernism, late modernism, high-tech, deconstruction, folding, field thinking, and more recently, topology, affect, technique, contemporary processes and all things “post,” these developments have helped shape recent discourses in architecture, particularly in education. While many contributions have been made, these histories seem exclusive, frequently leading to autonomous and non-participatory architecture. A projective positioning of design methods would augment these spatial and discursive developments, offering footnotes to these more dominant histories by leveraging another scope for architecture.

Critical method involvement might shed light on much that remains unquestioned and accepted by default - valuing speculation, authentic spatial production, and the expansion of architectural knowledge by grounding itself in the cultural, ethical, material, and methodological aspects of spatial production. To accomplish this requires contextualizing discussions and developing a diverse range of skills, not the least of which is engaging with multiple value systems and aesthetic possibilities. Design method expansion can play an important role on this front.

14 DESIGN METHODS, OR 11 DESIGN METHODS AND 3 TECHNIQUES: WORKING NOTES

I’ve identified 14 design methods - they aren’t ‘correct’ or the only ones. They are, however, diverse in make-up, highly varied in operating potential and capacity. Their use facilitates radically different outcomes. They can be combined, translated, tailored, and even invented, tuned to the particular questions at hand.

With respect to design, some methods are direct, others more indirect, some requiring modes of translation or affiliations with other design methods. On the ground they are linked with various kinds of representation techniques - 2D, 2½D, 3D, and other Ds. To avoid confusion, these thoughts focus on the design methods themselves, rather than on the techniques of representation that might be linked to particular methods. The fourteen are organized alphabetically with a couple of points made about each method. To establish some range in method diversity, four of them - syntactical means, gestural translation, appropriation, and analogic means are drawn out and supplemented with work samples.

1. “Analogic” means for design works through likenesses - “this form is like that”, “this behaves like that” and so on.
2. “Appropriation” as a means to work is to find or to take for one’s own use or to take (im)properly, as with(out) permission.
3. “Automatism” defies logic and rationality, attempting to remove obstacles to the creative imagination - André Breton defined surrealism, for example, as “pure psychic
4. A “content to form” means of working begins without material or formal destinations - the method enables a designer to work from issues, topics or ideas toward producing spatial conditions.

5. “Diagramming” (one of the three methods identified here that might more accurately be a technique - indexical and notational means are included in that possibility) sets a fabric of information into play - relational assemblies visualized through abstract visual means.

6. The “form to programme” method (attributed to architect and educator Kevin Rhowbotham) of designing challenges “form follows function” spatial agendas. In this design method, formal and material possibilities precede program logic, opening the expansive possibilities for both what form and programs might be.

7. “Gestural translation/interpretation” suggests a two-part sequence - one of gestural generation and one of translation or interpretation. This method frequently occludes or delays meaning or content in lieu of another way to generate form.

8. “Indexical means” for working is one of the least direct relative to architectural production. This method is often detached from form and temporal circumstances, instead pointing to other things through developing indexes arranged or deployed, indirectly toward spatiality.

9. If “analogic” means trades on likenesses, then “metaphoric” means trades on differences that are brought together where a word, phrase or thing that normally designates one thing is used to designate another, making an implicit comparison.

10. The “narrative” design method uses the familiarity of storytelling, enabling a designer to set up a narrative construction, following it as a guide for designing. Notably, this differs from narrative as sought after meaning or communication in a piece of work.

11. “Notational” means for working negotiates parts of a schema, enabling something to be enacted over and through time—a kind of coded matrix of time and space potential.

12. “Parametric modeling” is fairly common these days. Here, the author selects any range of variables, commonly within a familial range, and subsequently develops representational abstractions of those chosen parameters, frequently qualified by software protocols.

13. And then there’s “plagiarism”—the copying and taking someone else’s work and claiming it as your own. Without condoning it, this form of working is legitimate, but has many ethical questions attached to its operating agendas.

14. Finally, “syntactical” means for working enables the development of architecture through iterative operations or rules, normally formal and usually devoid of political, social or experiential grounding.

DESIGN METHOD CONSIDERATIONS

When engaging design, the terms of design methods are seldom explicit, frequently leaving a designer isolated and lacking a contextual and operational background from which to design. These circumstances render students and professionals underprepared to optimize the opportunities that significant shifts in cultural, technological, and temporal conditions afford. If key considerations are taken seriously, the potential for design method involvement toward increased design versatility, innovative spatial make up, constructing disciplinary knowledge, interdisciplinary connections, and a real politics of communication are extraordinary.

It is critical to lay bare the cultural and architectural context in which methods and their attendant values were developed, worked with, and transformed. Methods have distinct characteristics - from operating protocols; to yielding form and material possibilities, or
not; and to the kinds of things that can be worked on in a project. Identifying key areas for framing methods is essential for optimizing what methods afford and include: the etymology, or origin of a method; its operating preferences, biases, and limitations; the roles of the author(s); the (in)directness to get to form when designing architecture; its extended referential structure; developing a template for operations - a kind of road map - for implementing a given method; case studies; and means for assessing the methods’ use.

Some methods are linked to particular cultural movements and developments - “automatism” to Surrealism or “parametric modeling” to developments in mathematics and the sciences. Others evolve in more informal ways, accumulating density through practices over time - “appropriation” comes to mind. Still others are more approximately formulated, loosely tied to cultural practices from art making, to writing literature, and to the animate potential of our bodies - “gestural translation.” Regardless of the method’s origin, it is important to understand them as grounded in the history of ideas, in the world of cultural production, and in the spatial settings of our lives, both real and speculative. It is crucial to qualify them relationally - rather than as hermetic and autonomous slaves at our beckoning call.

METHOD PROFILES

Locating design methods in a larger context is paramount to their effective use - knowing that some are linked to spatial practices, others to art, and some to literature and the sciences. Articulating a method’s etymology, culturally and architecturally, locates it in the larger history of ideas, establishing dialogic continuity. Identifying the progenitors, offspring, and known trajectories of a design method is equally important.

When considering the preferences of a method, it is important to specify what it does well and what kinds of things it does not allow. A “narrative” means for working (not narrative content), for example, may not allow accidents or chance, whereas “automatism” suppresses rationality and embraces spontaneity and chance through un- or subconscious forms of authoring. Where “automatism” supports the irrational, “parametric modeling” values selecting variables, firing on the logic and curatorial virtues of the author and the biases of software application. Understanding whether a method leads to making form, to meaning, abstraction, informational relations and authorial power is also significant. This understanding contributes to the possibility of a more effective method use over default means for designing.

The roles of the author vary significantly from method to method. Some methods lend themselves to single, multiple, or other kinds of authors. They require different kinds of energy to work - reflective, cyclical, spontaneous, disciplined. Some suggest making judgments as the design process evolves, others don’t. In the “content to form” method, for example, assessments might be made regularly, yet when working “automatically” judgment would be avoided. To reflect on authorial roles (even within design methods that attempt to remove the author – self-generating methods, for example) is important in positioning and using various design methods.

Some methods lead to an architectural or spatial result quickly and directly, whereas others are linked to subsequent translations and interpretations. Working through “indexical” means, for example, requires making translations, whereas with “appropriation” or even “analogic” means, a spatial result may be almost immediate. The directness, or indirectness, toward spatial make up has several ramifications, not the least of which relates to the efficacies of decision-making, form, or not, and speeds for working.
When using design methods it is useful to determine whether one is responsible for extended relations, and if so, what kinds of opportunities might be engaged? When working “syntactically,” for example, the work is likely to be autonomous, or self-contained, whereas “appropriation” is referentially woven. Challenging the autonomy of a method is essential – necessary - if trying to increase the versatility and dexterity of a designer.

It has proven extremely productive to identify the ingredients and choreography of variables needed to work with design methods - developing a kind of template for operating. Seldom do designers work with a single method, and it may be necessary to invent new methods, to combine or hybridize them. In any case, it is useful to understand the operating sequence,
to anticipate when a particular means for working yields to another method, and what kinds of representation techniques are productive and where form and material make up might come into play. Here, developing confidence in deploying any range of methods by making familiar a sequence of operations that are attached to a specific means for working.

4 DESIGN METHODS + WORK SAMPLES

Syntactical Means: Framing

In linguistics, syntax is the study of the rules and principles that govern sentence construction, and in mathematics the term relates to the rules that structure its systems. As a design method it is normally used to develop formal grammars. We might trace its use to the Neo-Classical architect J.N.L. Durand (1760-1834) and his combinatorial use of modular units that anticipated industrialization and totalized systems thinking. More recently, Peter Eisenman's early houses are an example of rules systematically pursued through drawing operations, enabling a formal grammar with an occasional material coding.

In (Figures 1a-6a) students in a seminar were asked to develop a set of rules or guidelines to produce spatial formations digitally. They were encouraged to use software such as Rhino or Maya rather than Photoshop or Illustrator. Each student developed systematic instructions - extrude, bisect + code, rotate + loft, re-scale, reverse inflect, for example. The degrees to which the procedural design steps were recognizable in the final formations were left to their discretion. The site for this work was abstract, comprised of 6 1/3 alphabet-like letterforms. The letterforms could be scaled, nested, arrayed, or distributed according to a developed rule set. The letterforms were pink and yellow, they could be opaque or gradated, and they could be 2D, 2½D, or 3D forms, digitally modeled.

Gestural Translation/Interpretation: Framing

Gestures are non-verbal communications in which bodily actions articulate any range of things through the movement of the face, hands, or arms. The word translation originates from Latin, meaning “to carry across” or “to bring across”. Our bodies are simultaneously highly evolved and primitive, loaded with potential to articulate spatial or pre-spatial formations. A design method that trades on body potential, gestural translation requires translation from the gestures to the possibility of actual spatial formations. For example, imagine two to three people gesticulating wildly to a favorite Michael Jackson tune or dancing the salsa, capturing those moves on eight axially oriented video cameras, and then downloading and translating the temporally constructed spatiality as an architectural formation - implicating geometry, movement, speeds, and intensity in the formal and material possibilities. Or, how about a spontaneously created red lipstick wall drawing, enacted over different periods of time, with a pheasant feather pinned quickly onto the wall drawing - sequentially translated through forms of digital modeling, implicating position, geometry, and materiality. Parenthetically, the gestures can be forethought, invented on the spot, a series of reactions to other forces, or a combination of all of the above.

So, there are the characteristics of the gesture(s) and the translation. Then, in the work shown here (Figures 1b-6b), there is the aspect of situating the formations, representationally. In this case, the site for the generated spatial formations came from images of drawings by one of three French, Neo-Classical, visionary, and, some would say, revolutionary architects’ spatial speculations – Etienne-Louis Boullée (1728–1799), Claude-Nicolas Ledoux (1736–1806), or the slightly lesser known Jacques Lequeu (1757–1825). Their drawn proposals for the ‘Cenotaph for Newton’, the ‘Temple of Equality’, the ‘Temple of
Death’, the Elephant monuments, and so on were fair game. Each student worked with a section from one of these architects, occupied with the relational properties of the section, its representation techniques and any other aspects of the appropriated image in the relation to the gesturally motivated and digitally translated work.

**Appropriation: Framing**

In the arts, appropriation is the use of found or pre-existing objects or images without change or little change to the original material. While established through the development of things such as cabinets of curiosity or wunderkammer in the 16th century, appropriation was ushered in as a legitimate form of cultural production by artists such as Pablo...
Picasso and Georges Braque in the early 20th century - and by the Surrealists and Dada artists, most notably Marcel Duchamp, a few years later. Arguably, appropriation became a pervasive, almost symptomatic face of identity for the 20th and 21st centuries. Linked to practices of collage, assemblage, and photomontage, this method allows the artist to produce new work by gathering existing material and combining it with things from another context - bringing together distant realities to produce new forms of cultural production. Anyone can do it; there is no special training or context for using the method required.

In the work shown here (Figures 1c-6c) the students found and used appropriated
Figure 1d Graphic Analogic Construct

Figure 2d Graphic Analogic Construct, Motel Desert House + Garden, Plan

Figure 3d Analogic Construct Museum for Things RE(A)D

Figure 4d Spatial Syntax Analogic Construct Museum for Things RE(A)D

Figure 5d Motel of Multiple Psychologies Motel, Aerial View

Figure 6d Motel of Multiple Psychologies Motel, Aerial View
material, downloads, or scans to produce a flat graphical surface - an image of a possible architecture, situated in the space of a found photograph: a painted ceiling; an aircraft carrier deck; a rock quarry. Sensitivity to the qualities of the given photograph and of the appropriated material assembled toward an architectural possibility was more important than the constructability, program legitimacy, or so-called content of the spatial proposition. It was suggested that the students might be collecting parts of many things that did not know what they could become collectively. Borrowing from analogic thinking - to help flesh out architectural possibilities, the overall formation might be something like a bagpipe crossed with a B-52 bomber with a dash of time-lapse photography tossed in for good measure. Or, the spatial formation might occupy the curtain wall surface like a corsage on a wedding dress, while moving like an Epson scanner with a stutter, only in the dark.

Analogic Means: Framing

Derived from the Greek analogia, this design accomplice operates through likenesses; that is, “this looks like that,” “this behaves like that,” “this is materially like that.” Analogous thinking can be a proactive ally for the architect, brokering deals with objects, events, and phenomena out of one’s design grasp, increasing the pool from which spatial potential might emanate. Analogous thinking can also break down categorical and disciplinary silos, opening up formal, material, and behavioral range for design opportunities. It is a colloquial design method, easily accessed, and it increases our design capacities a hundred-fold, at the flip of a switch. The use of analogic production is a specific kind of appropriation where anything can be used as grist for the creative mill. This range includes fragments, wholes, and combinations of formal, material, behavioral, and operational attributes of a thing, an event, or even a conceptual structure.

Several interesting questions arise in the framing and use of this method, including questions about so-called authentic production, the (in)directness to architecture and challenges to legitimate subjects for architectural production. For many students, this particular method has proven to be enormously valuable, by increasing their material and formal vocabulary, or the potentials for both, remembering that as designers we often don’t yet know what things are, but we have some sense of what they might be like. For example, imagine that the section through a living space in a house is like a section through a French horn, the envelope for the space is clad in materials that are like the surface of a B-52 bomber, crossed with graffiti and the ground plane is like a circuit board crossed with the game of Monopoly.

In these examples (Figures 1d, 2d, 3d and 4d), there is a single image of an analogic construct, meant to provoke the imagination about where the likenesses might lead in the architectural or landscape proposal. In the last two cases (Figures 5d and 6d), the examples are images of an analogic construct on the left side, and the spatial translation or spatial proposition on the right.

CONCLUSION

“The term method has to have laid aside its modern and Cartesian intention of objectivity in order entirely to enter the service of the subjectivity that forms itself immanently. What had constituted its meaning for theory, its communicability, without any remainder, from individual to individual and from generation to generation is negated here. Method is precisely what the fathers always fail in and what grows out of opposition to them. For Riemer, Goethe explains this as follows: “Method is what belongs to the subject, since the object is, after all, familiar. Method cannot be handed down. An individual from whom the
same method is a need must find it for himself. Actually only poets and artists have methods, since what matters to them is to come to terms with something and to set it in front of themselves.”

Work on Myth, Hans Blumenberg, 1985

Significant changes in cultural paradigms, global dynamics and the practice of architecture, and importantly, architectural education, suggest that versatility and conceptual broadening may be a viable alternative to increasingly dominant forms of specialization and schematic spatial production. Design method breadth is crucial toward this possibility. As mentioned, increased sensitivity to method involvement suggests a range of provocations for the architect, including the roles of the author; the purity of a given method in its implementation; the preferences and limitations of a method; how quickly any given method enables architectural results; and the representation, or material techniques that effectively provide engagement with any range of methods.

On the one hand, the conceptual range through which we understand architecture to be possible seems limited, necessarily by a range of legitimate concerns. On the other hand, investing in design methods might liberate the ways in which we imagine spatial potential. With the confidence of familiarity of diverse design methods and experience by implementing several of them - and their possible combinations, sequential choreography, morphing - one might also broaden the conceptualizations of architecture, broadening disciplinary knowledge on several fronts, including the changing roles of authorship, programmatic breadth, typological reframing, and technique expansion, to name a few. For example, with the confidence of a content to form design method, or analogy as a means for working, one could conceive an architectural approach for duplicating a domestic interior, sending the clone into the neighborhood to co-mingle with other houses. Or the daytime advertising façade of a Home Depot might reconfigure itself to become a nocturnal agricultural surface, or suburban backyards might regenerate themselves to become ecologies of fish markets at dawn and a bioluminescent electromagnetic field by night. If thinking about certain biological processes, or smart and self-generating logics, analogically, architecture could scan a site and diversify land use options whilst on the run. Or, architecture might grow, delete, and regenerate aspects of itself whilst morphing the regenerated parts into another form through activated self-learning response systems. If we were to deploy ventriloquism, again analogously, we might be able to materialize the virtual space of a building’s construction rather than the building itself.

Varied situations in which an architect might work, do design research, or aimlessly probe curiosities also suggests varied, perhaps radically different, approaches to design. Designing parts of a new city in China might require different design methods in relation to design research invested in crossing metaphors, data, and narrative interests toward a spatial proposition. Or, working on transforming the ornamentation of the interior of a Las Vegas casino might be more effectively engaged by using design methods related to the interests of the project - rather than using the same design methods for a visionary project about floating bird motels, cloud harvesting, and bio-morphic interests.

I argue that we are likely to work in different circumstances, both real and speculative, over the course of our time in the discipline of architecture. In terms of real cultural agency and durability, it seems obvious that we might need to act differently in different circumstances. Diverse design method understanding could go a long way toward optimizing the intersection of the capacities of the architect, design methods, techniques for working, cultural and disciplinary contribution and the ultimate spatial production in
particular situations - represented or materialized.

Optimistically, we can position work and the means for working in relation to the ethical concerns of the architect, attempting to locate them discursively, culturally, and disciplinarily. Ultimately, investing energy in the scope of architecture - what it might take on ethically, culturally and situationally. The contributions of increased method awareness toward producing spatial make up play no small part in training the spatial imagination and the optimization of architecture’s cultural power, grounded in creative participation. On one hand, it is shocking how teaching design method deployment has gone missing. On the other hand, our catatonic condition might be revitalized, using appropriation and biological processes in this case - using respiration as a metaphorical catalyst - once again breathing life into our beloved discipline and the cultural agency of architecture.
Hybrid design workflows of digital crafting and material computation

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ABSTRACT
In this paper, we are presenting a number of research projects, which illustrate a design methodology developed by Research Cluster 6 (RC6) of The Bartlett’s Graduate Architectural Design program, positioned on the overlap between the digital (agent-based design strategies and generative form-finding) and analogue computation strategies (material behaviour and crafting techniques). In that context, RC6’s agenda argues for a new kind of craft, rooted in a thorough understanding of traditional, hands-on craft combined with expertise in contemporary computational concepts. In this regard, research presented in this paper primarily focuses on merging traditional, low-tech manufacturing processes with advanced technological approaches to design and realise new spatial concepts. The two projects presented in this paper, SanDPrint and FaBrick, address these premises through custom developed form-finding and fabrication processes, and test them through 1:1 scale prototypes.

INTRODUCTION
In this paper we discuss the design methodology and research approach carried out by the Bartlett GAD Research Cluster 6 (led by Daniel Widrig, Stefan Bassing and Soomeen Hahm). This is done through the presentation and breakdown of unique workflows, which re-evaluate the role of craft and hands-on production in the digital design domain under the umbrella of the “Crafting Space” agenda.

The research agenda of RC6 argues for a new kind of craft, rooted in a thorough understanding of traditional, hands-on craft combined with an expertise in contemporary computational concepts. The conducted research primarily focuses on merging the traditional, low-tech manufacturing processes with advanced technological approaches to design in order to realise new spatial concepts. In that sense, it is positioned on the overlap between the digital (generative form finding) and analogue computational strategies (material behaviour and crafting techniques). The emphasis here is on exploring the methods for overcoming the discrepancies between the top-down and bottom-up decision making processes, while exploring the benefits of previously mentioned different design inputs - material behaviour, generative agency or human/designers’ input.
This was done through a series of individual architectural scenarios / research projects, which address these premises through custom developed form-finding and materialisation processes. These ideas as well as the resulting research and educational projects will be demonstrated in the paper. All of the proposals - prototypical structures, architectural objects and products - are built and tested in a 1:1 scale.

RESEARCH CONTEXT

With the advent of new digital design and manufacturing technologies, designers are working at a pace and resolution unimaginable just a few years ago. Digital systems allow designers to accumulate, structure and utilise massive quantities of information to parametrically shape products and the built environment. Likewise, the corresponding fabrication technologies, such as 3D printing or robotics, synthesise these projects in an increasing scale and resolution, employing rapidly expanding ranges of “digital materials”. While these software and hardware systems facilitate rapid design and production, tactile interaction with form and matter throughout the design and fabrication process is increasingly scarce.

Following the application of such systems, new sets of questions, constraints and concerns emerge. While we are now able to rapidly materialise almost any form, we are struggling with issues such as high cost of parts, limited material choice and large-scale applicability. In addition, fully automated fabrication systems often force designers into rather linear production pipelines with little room to manoeuvre or improvise. Since machining is expensive and time consuming, the actual process of making is often delayed to the very end of the design phase, usually delivering highly predictable, pre-simulated results. In such workflows notions of spontaneity, artistic intuition and noise are usually undesirable.

In this context RC6 seeks to explore hybridised design and fabrication models, in which tactile interaction with materials and form initiates and drives all research efforts. We embrace messiness as opportunity, and failure as part of the invaluable learning process. We are particularly interested in novel combinations of analogue and digital methods in which hands-on and computer controlled design and manufacturing operations do not just co-exist but overlap. With the research in such customised, semi-automated processes RC6 engages in the evolution of a new, crafted aesthetic, one that reflects a shift from an architecture predominantly interested in representation and tools towards an architecture that brings new notions of craftsmanship, intuition, and a post-digital design sensibility.

FABRICATION AND MATERIAL SYNTHESIS

A number of design and manufacturing disciplines, such as fashion, product and automotive design, are rapidly adapting to previously mentioned new fabrication technologies - particularly additive manufacturing or 3D printing of market-ready products. Noteworthy examples of this include works by fashion designer Iris van Herpen, who utilises rapid prototyping to produce couture pieces, as well as Nervous System - a design studio which works at the intersection of science, art and technology and utilises digital fabrication to create affordable art, jewellery and housewares. In contrast to this, rapid prototyping in an architectural context is still mostly reduced to being a fast and painless way of creating representational models, instead of using its potential for architectural production and to bring a new materiality into the architect’s increasingly virtual studio. This is at least partly due to the fact that, until recently, only the larger, commercial practices and institutions could afford this expensive equipment. The reduction in cost of these machines, coupled with the general democratisation of tools (soft- and hardware) will change this. The spread
of open source/DIY equipment, shared knowledge and innovation in the bypassing of patents both in terms of machine construction as well as the production of consumables now allows us to economically create complex parts, enabling smaller studios to utilise these systems.

Material research and material computation are often dealing with the post-construction lifecycle of the object. Their translation into computational models is limited to material property simulations within the closed linear system of design and production, missing the tactile interaction between the computer generated form and matter.

Likewise, the application of cutting-edge fabrication techniques such as 3D printing and robotic fabrication is often constrained to predefined modes of production. In such cases, the manufacturing technique is disconnected from the design process and used purely as a means of production of advanced and intricate geometries, without the direct feedback between the two. Examples of such application can be seen in the pioneering 3D printed work of Behrokh Khoshnevis at USC and Enrico Dini of D-Shape.

With the increasing affordability of 3D printers, and recent developments of affordable robotic arms [EVA by Automata Technologies], it is inevitable that such tools will become an integral part of RC6’s two-fold approach. However, in spite of advanced material research and robotic fabrication booming recently [Achim Menges at ICD Stuttgart, Gramazio&Kohler at ETH, MIT Mediated Matter group], these avenues of design research are often disconnected. In the robotic fabrication process, machines are often used as end effectors, pre-programmed to deposit (extrude, cut, aggregate) the material as intended by the design, creating 1:1 representation of computer generated form. Robotic fabrication workflows should come from fabrication techniques and inherited properties and latent qualities of used materials, creating a feedback loop between machine and material limitations and properties, and the design, which evolves through received feedback.

**GENERATIVE DESIGN TOOLS AND METHODS**

With all of us more and more dependent on ready-made fabrication strategies, pre-made scripts and black box (“off the shelf”) technology, an unbiased evaluation of our computational design culture is increasingly difficult. Within that context RC6 seeks to re-evaluate the role of craft and hands-on production in the digital design domain. This is done through continuous exploration in hybridised design and fabrication strategies in which digitally-controlled techniques of form-finding and manufacturing naturally blend with existing crafting techniques and low-tech ways of making.

In regard to application of off-the-shelf software packages in architectural practice and academia, Senske (2014) notices the importance of designer’s thorough understanding of the used tools, where using off the shelf packages often results in designers using tools without comprehension of the inner working of the tools themselves.

There is no denying that algorithms are becoming an inseparable part in the processes of both the design and production of complex geometrical solutions. However, here the algorithmic approach is often used as optimisation strategy or for geometry rationalisation. Such examples can be seen in the work of Philippe Block and his research group at the ETH Zurich, which is efficiently using topological analysis algorithms in order to simulate and resolve structural issues in the design of shell structures. The project for Qingdao Cultural Centre by ZHA utilises rain-flow analysis algorithms as a means of phenomenological articulation. Here the perceptual identification of functional units and their relations are
facilitated by the surface articulation of the structural shells, derived from the algorithm. Examples of custom applications, such as processing libraries do exist within the design community - iGeo by Satoru Sugihara or Plethora by Jose Sanchez, to name a few. However, as elaborate as they are, parts of such libraries are either focusing on a specific design problem, or are not directly built around a specific design workflow.

DESIGN METHODOLOGY - TOOLS, GENERATIVE METHODS & AESTHETICS

Now in its third year, the RC6 - Crafting Space agenda argues for unique workflows, which form a seamless pipeline throughout the entire design process - from the initial concept stage to its fabrication. This comes as a result of a pursuit for new architectural aesthetics, which emerge from innovative way of thinking about material computation and fabrication, while at the same time searching for creative applications of available tool sets in combination with cutting edge technologies and computational powers. The resulting designs are derived from generative systems, which manifest the material behaviours. Manoeuvring between disciplines and techniques, RC6 seeks to occupy in-between territories where traditional and contemporary ways of designing and making blur into one.

HYBRIDISED WORKFLOWS

With this in mind, the presented design methodology combines top-down and bottom-up approach on one hand, and how manufacturing iterations and techniques feedback the computational models on the other. Here, computational models are not just representational, nor do they consist of material property simulations. In this sense, they are bound to fabrication logic and its constraints. Furthermore, they constantly feed back to the manufacturing process, effectively closing the design-to-manufacturing loop.

Throughout the year, RC6 traditionally works in multiple scales. With a particular focus on physical production, students gradually increase the scale and scope of their work through iterations of prototyping. Later stages of the research are dedicated to the development of a proposal in which material experimentation, applied prototyping, coding and modelling converge into a coherent architectural design proposal.

With regards to this, the proposed design approach is not technique biased. Meaning that we are taking an eclectic, multi-platform, multi-disciplinary approach, with the intention to hack into crafting techniques and corrupt digital workflows. In this sense, the research questions the following:

• Tactile interaction between digital models and physical products
• Black box technology and ready-made fabrication techniques
• The balance between the top-down and bottom-up approach, and the influence this balance has on the aesthetics of the product

In an attempt to achieve this, we are driven by material computation, material performance and its tectonics and the tactile feedback between the digital and physical. We are taking an holistic approach, where we look at the common methods between digital design and manufacturing processes, embedding the generative logic with fabrication constraints, resulting from analogue computation or machine/material limitations.

The analogue computation refers to exploration into material performance, physical manifestations of proposed systems and their tectonic protocols. The design systems are
firmly grounded in rigorous research on material behaviour, as well as in its formative and structural properties. From this material uncertainty and unpredictability of hybrid material systems, the true design research can emerge.

**DESIGN APPLETS**

Custom design applets, programmed in Processing, are developed to support design craft, and not a means for themselves, with the intention of closing the gap between digital simulation and fabrication. The goal was to create scenario specific applets/design engines, establishing the connection between initial inputs, which drive the design and its iterations, and previously mentioned design and fabrication constraints. This approach contrasts project specific scripts (one end of the spectrum) or black-box program packages, which are robust and overly ‘open’ (other end of spectrum).

As mentioned, the design process for each scenario was two-fold, addressing the fabrication techniques as the means of producing full-scale prototypes, and computational design techniques, which were guiding the design process and establishing generative logic. The computational techniques used in this process are primarily based on the application of multi-agent systems, as a means of achieving heightened control of architectural matter as well as producing novel spatial and formal outputs. Design applets are specifically designed for each of the testing scenarios, in order to respond to and engage with the selected fabrication techniques.

**CASE STUDIES**

The following chapter introduces student projects developed under the umbrella of the “Crafting Space” agenda. Projects developed within RC6 range from projects derived from a specific material or fabrication system to projects driven with a specific computational technique. While all of the projects address both material computation and application of generative design techniques, we can group the projects into 3 main categories, according to the dominant methodology that drives the process:

- Material behaviours
- Hybrid Material Systems
- Generative computational systems

However, this paper will focus on two projects that are centred around the investigation of material behaviour in conjunction with innovative engineering techniques. The point of departure in these two cases was an exploration into unorthodox material systems, rarely used within the building industry. Projects SanDPrint and FaBrick (which use sand and felt fabric respectively) illustrate the process in which such material system is driving the creation of an innovative construction method.

**SANDPRINT**

Starting from the interest in casting techniques using recyclable moulds, SanDPrint (Xiyangzi Cao, Shuo Liu and Zeyn Yang) conducted thorough research on a unique mould-making technique which uses rubber tubes and sand. The goal was to create an easily available and low-cost fabrication method, using abundant material in a way that is uncommon in everyday architecture practice, by simulating 3D printing with a low-tech crafting technique. Precedents of similar approach can be found in the works of Victor Castaneda, who developed a series of bowls made from casting plaster over naturally created divots, and Max Lamb, who adapted a primitive form of sand casting, filling the
relief carved into the beach sand with molten pewter in order to create furniture pieces.

In the SanDprint fabrication process the mould is formed from wet sand, which is placed around the rubber tubes. Once the tubes are removed, a casting material such as plaster, concrete or metal is poured into the holes. The curvilinear nature of the rubber tubes, in combination with the fine texture which would be formed on the surface after the sand was removed, provided the design of high aesthetic qualities through an easily affordable low-tech fabrication technique (Figure 1 and 2). In addition to this, a removable frame was designed to stabilise and control the direction of the tubes.

The rubber tubes had constant section, which in combination with rubber material flexibility and low friction allowed them to be extracted from the mould. Furthermore, the type of sand and grain size, as well as their combination with castable materials of different grains established the basic set of design constraints. Sand had to be of a grain small enough to capture the form created by the tubes, whereas the casting material had to be able to flow through the mould without blocking the tunnels. Likewise, the particle size and the drying speed of the sand affected the structural properties of the sand. In regard to the choice of casted material, parameters such as drying time, liquidity and permeability drove the decision towards plaster over resin, cement and a plaster and cement mixture.

Furthermore, the tubes themselves could be bundled only up to a certain point, since if the internal columns were too thick, the mould would internally collapse. In addition to this, specific tube curvature constraints were established. The tube curvature could not be too steep, as it would result in breaking the mould during the extraction process. These constraints – the angle of the branches and the number of branch generations - informed the digital models. Initially, this was translated into a generative process based on the logic of L-systems, which was used to generate the triple branching networked structures, which would later on be translated into tubes for fabrication.

Applying the mentioned constraints derived from the material system, a specific design language of bundled curves was developed. The patterning language was informed by three principal operations of tube cohesion, tube rotation and combination of the two (Figure 3). The digital system would take into consideration parameters such as the maximum number of bundles per column, minimal distance between bridging points, and curvature constraints. Based on the conclusions of initial digital studies, a more elaborate
Figure 3 Tube patterning operations // GAD RC6 / Team SanDPrint: Xiyanzi Cao, Shuo Liu & Zeyn Yang

Figure 4 Processing simulation and patterning study // GAD RC6 / Team SanDPrint: Xiyanzi Cao, Shuo Liu & Zeyn Yang

Figure 5 Full scale SanDPrint column prototype // GAD RC6 / Team SanDPrint: Xiyanzi Cao, Shuo Liu & Zeyn Yang

Figure 6 Interlocking column detail // GAD RC6 / Team SanDPrint: Xiyanzi Cao, Shuo Liu & Zeyn Yang
generative process was established, based on multi-agent systems. Here the agent behaviour was informed with the same constraints and parameters, while the tubes were derived from agent trails (Figure 4).

All of the furniture scale prototypes were designed with 1:1 parameters in mind, where the number of agents/trails and distance between them would take into consideration diameter of the tubes that were used in the fabrication process. Following this, larger scale structures were also further tested digitally. The size of the each fabricated object was essentially limited by the size of the supporting frame. In order to efficiently fabricate larger pieces, techniques such as distributed casting, continuous casting, as well as the interlocking of smaller casted components were tested (Figure 5 and Figure 6).

FABRICK

Inspired by the dramatic advances within the field of textile and fashion design, the FaBrick project (I-Ting Tsai, Somdatta Majumdar, Xixi Zhend, Yiru Yun) investigates the correlation between the development of new material craft in the form of couture architecture and the architectural design and fabrication process. With the idea of developing quick and easy methods for designing and fabricating space, this couture architecture project examines the wider implications of textiles in space creation, changing the way that fabric is perceived in architecture. The project links fabric manipulation processes, typically used in the fashion industry, with digital modes of design and fabrication, creating a new typology of fabric architecture.

Traditionally viewed as a flat and two-dimensional material, fabric has mostly been used in architecture as a surface sheet and roofing material, without fully exploring the material’s versatility. With this in mind, FaBrick conducted research into a composite material system using felt fabric, and resin, with the fabric as primary structural material, rather than a secondary element to other components in the structural system. The material properties of felt were used to produce 3-dimensional structures from 2-dimensional sheet material by traditional stitching techniques. Softness and malleability of the fabric were used as an advantage in the process of forming complex geometrical shapes.

The fabrication process would start by cutting a pattern in the material and stitching the fabric along the cut seams (Figure 7). The shape of each prototype piece was created by cutting out sections from a flat sheet of fabric using a laser cutter. The fabric would then be stitched and folded into one of the three types of formal components (Figure 8):

- Surfaces and creases
- Holes and tubes
- Cut slits

Initially fabric would be moulded into pipe-like structures that could support the weight of the remaining material. After the rest of material is stitched and shaped the hardening material cures to create a completely self-supporting object. Here, different composites (mixtures with wood glue, resin etc.) can be applied to a single piece of material, creating varying levels of rigidity. This logic has been carried further as the main structural principle in the process of production of 1:1 prototypes (Figure 9 and Figure 10). Load-bearing elements would be folded into tubular sections, ensuring stability. The idea here was to create a continuously connected “structural skin”, which gradually transitions from linear (tubular) elements, to surfaces and volumetric shapes. These elements would be further combined and reinforced with seams and ridges - transitioning from 2D to 2.5D elements.
Further folding of the tubular and surface elements would result with 3-dimensional arrangements. This allowed for the creation of objects with varying surface and structural properties, depending on the applied formal components, as well as on strategic placement of rigidifying composite material.

The digital workflow itself was set up in order to develop two different aspects of the project in parallel - simulation of stitching and aggregation of smaller objects. Due to the size constraints it has become apparent that in order to scale-up, prototypes could not be made out of a single sheet of felt, but would rather be created as an assemblage of interconnected smaller pieces.

Simulation of high-resolution fabric is computationally very expensive, and reducing the resolution of digital models would result in loss of complexity in comparison with the physical experiments. With this in mind, it became apparent that a hybrid approach of multiple digital strategies (combining generative and explicit modelling) and constant
feedback between digital and physical models based on material limitations is of absolute necessity. This directly influenced the digital simulations, which focused on developing the relationship between two-dimensional patterns of felt sheets and three-dimensional geometry, through simulation of folding and stitching behaviours. This relationship between the two-dimensional patterns and the resulting 3D geometry, as well as the design language of travelling seams which would act as the connections between smaller components, presented the basis of the FaBrick digital design repertoire, where different digital techniques were used for simulating different formal components. While surfaces and slits were treated with fabric simulation engine and generative methods were established for creating of tubes and holes, slits and seams were generated through explicit modelling techniques.

CONCLUSION

The presented projects illustrate the importance of closely integrating digital crafting techniques with fabrication protocols, as well as the importance of establishing constant feedback between the two. This can effectively be achieved through the use of custom design applets that take the design methodology as the common denominator for the two ends of creative process. This approach creates a general framework for design research without being overly prescriptive, allowing for the unexpected and novel outcomes to emerge.

While navigating between digital and physical worlds, the approach of crafting agency is able to produce results of high complexity and resolution, while being able to offset the imprecisions in the manufacturing process, unlike the standard linear fabrication processes. This comes as a result of embracing the noise and failure as integral part of the design process, which combines analogue and digital modes of production as inseparable parts of complex design ecology.

CREDITS

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REFERENCES

Research-based teaching as a search for novelty in architectural education

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ABSTRACT
This paper argues that a reconsideration of architectural education as a project may enable us to articulate teaching and learning processes as research practice itself, which aims at the development of new possibilities of architectural creation and the generation of architectural knowledge. In this paper the term project is used not in merely architectural terms but rather as a search for novelty, the main motivation of all kinds of architectural creation. Novelty is emphasized as a precondition of architectural creation, as architecture is always about the new, beyond the established.

The paper inquires teaching and learning practices in architecture as interconnected processes in which knowledge emerges as a result of a search for novelty. It is underlined that novelty may emerge when research-based knowledge enmeshes with experience-based knowledge in architectural education. The debate on teaching and learning in architecture as a search for novelty dwells upon three main topics: (1) reflection in teaching and learning (2) teacher-student dialogue, and (3) theory-practice nexus in architectural education. Firstly, the paper examines how reflection on theoretical knowledge and experiential knowledge influences our learning and understanding of the teaching and learning processes, the methods, tools and outcomes in architectural education. It is discussed that reflection is needed not only on knowledge about teaching and learning, but also on how that knowledge is acquired. Secondly, the paper focuses on the role of the student as the active subject of learning process, and that of the teacher as an adult learner, researcher and an advisor to the student. Thirdly, the paper stresses on the ways new experiences generates new knowledge and new knowledge leads to the development of skills and expertise for teachers. The paper finally asserts that in the condition that the teacher as practitioner, learner and researcher acts as the generator of new architectural knowledge and experiences, experience-based knowledge and research-based knowledge merges on the basis of project-based knowledge in architectural education. When we reflect on and call into question our thinking and practice of architectural education, teaching and learning becomes under continuous review and transformation, generating new knowledge and revealing new conceptions and insights for architectural education.

INTRODUCTION
The need to reconsider university education as a comprehensive process is at the center of debates in higher education, since the formation of “communities of learning, dialogue, research, and practice” is seen as the primary mission of a modern university (Pardales and Girod, 2006; Mavroskoufis, 2012). The
position of architectural education as a form of professional education at the university context deserves a special attention within the framework of these debates. By emphasizing the comprehensiveness of architectural education, this paper investigates research-based teaching as a search for novelty in architectural education.

The development of graduates as competent practitioners, promising architects, and well-equipped individuals are essential goals of professional education in architecture. The pattern of teaching in professional education is different from other forms of teaching. The intertwining of specialized knowledge and technical expertise with a capacity for analytical, critical and imaginative thinking is the ground on which architectural education is situated. Within this framework, architectural learning and teaching develop as forms of doing that occur in experience. Learning by doing, inquiring, experimenting and synthesizing are the prominent tools employed. A learner-centered educational approach is indispensable. Learning environments as such becomes places in which the encounter of students with academics occurs in dialogical and collaborative ways. Learning environments in schools of architecture rely heavily on collective engagement of both academics and students in research throughout the educational process, which primarily aims at revealing the potential abilities and competences of learners rather than transferring knowledge. Research-based teaching and learning as reciprocal activities are at the center of architectural education.

In this paper the term research-based is used in the sense that Ron Griffiths (Griffiths, 2004) puts it:

“… the curriculum is largely designed around inquiry-based activities, rather than on the acquisition of subject content; the experiences of staff in processes of inquiry are highly integrated into the student learning activities; the division of roles between teacher and student is minimized; the scope for two-way interactions between research and teaching is deliberately exploited”.

Research-based teaching encourages students to learn through inquiry when the act of teaching transcends the transmission of knowledge and becomes a process of continuous investigation and reflection in which the teacher continuously learns. A dialogue and interaction between the teacher and students is essential. Research-based teaching aims at cultivating students with the knowledge, skills and attitudes they need to learn how to learn. At the same time, learning how to teach becomes a process of self-discovery and self-empowerment. In other words, teaching becomes a new task to learn. Students, on the other hand, should take more active and efficient roles in the learning process. In research-based teaching, the emphasis is more on the process and problems engaged with, rather than the product (Healey, 2005).

Taking the notion of research-based teaching as its starting point, this paper aims to open discussion on architectural education as a project. It argues that to reconsider architectural education as a project may enable us to articulate teaching and learning processes as research practice itself, which aims at the development of new possibilities of architectural creation and the generation of knowledge. In this paper the term project is used not in merely architectural terms but rather as a search for novelty. Novelty is emphasized as a precondition of architectural creation of all kinds. Architecture is always about the new, beyond the established. It generates a curiosity to explore the multilayered nature of problems in the built environment. Architecture opens “new ways of seeing and depicting the world,” to use the words of Michael North (North, 2013). It would not be a
misinterpretation to say that economic, political, social or cultural changes also change the responsibilities of the architect, the nature of knowledge and the ways of approaching knowledge. Architectural education gives space to curiosity and familiarity at the same time, while promoting a search for novelty. Novelty in architectural education derives from the attempts to advance knowledge needed to develop architecture as a discipline. The development of academics and students as active participants of a community of learners also makes contributions to go beyond the established.

Three primary components of architectural education as a project can be defined as (1) the teacher, (2) the student and (3) pedagogy (Spiridonidis, 2014). An analysis of how these components interact with each other may help better understand how architectural education acts as a project. In this paper it is argued that teacher-student-pedagogy interaction informs the ways teaching and learning and research informs each other.

Different conceptions of knowledge inform the ways research is conceived. There are varying conceptions about the nature of knowledge and research. Accordingly, teaching and learning are defined in numerous ways, and there are differing discussions regarding the roles of teacher and student within teaching-learning-research nexus. This paper underscores that by its very nature research is practiced through teaching and learning experiences of all actors involved in the process of architectural education. The paper also attempts to re-contextualize the teaching-learning-research nexus in architectural education into the debates on the notion of scholarship. As underlined by Angela Brew (Brew, 2003), “[d]ifferent ideas about the nature of research, scholarship, teaching and knowledge have different consequences for how we bring teaching and research together”. Scholarship, defined as the essential basis of the academic communities of practice, opens a fertile ground for any attempt to reconsider the roles of both teacher and learner as researchers in the process of architectural education. Architectural education is a community of teachers and students who continuously learn from each other and generate new knowledge through their joint effort.

THE NATURE OF RESEARCH IN ARCHITECTURAL EDUCATION

In the view of Ron Griffiths (Griffiths, 2004) “systematic process of investigation”, “advancement of knowledge” and “opening to the public” are the main requirements of any research act. He mentions:

“To count as research, an act of inquiry or ‘finding out’ is generally expected to involve a systematic process of investigation - i.e. one that is carefully designed and executed with regard to relevant methodological principles. It is also expected to be aimed at advancing knowledge within the field of inquiry, and not just acquiring information that is new to the inquirer or needed for an immediate practical task. The findings and the methods are expected to be made public, so that their validity, and their contribution to the existing knowledge base, can be assessed by the wider community of experts in the field”


This definition has important implications for the conception of research-based teaching as a search for novelty in architectural education. The ‘finding-out’ nature of research act should not necessarily imply uncovering what already exist, or bringing into light that which has already been established. It also implies the development of the ways to look through new perspectives and possibilities. This sheds light on the informative nature of research and establishes the connection of research with teaching and learning.
experiences occurring in the education process. This connection is summarized by Burton Clark (Clark, 1997) in the following words: “[r]esearch activity can and does serve as an important mode of teaching and a valuable means of learning”. It is evident that the conception of research under consideration is not on an “atomistic” one “where the intention is to produce an outcome”, but rather it is based on an “holistic” conception of research “with an orientation towards internal processes and where the intention is to understand” (Brew, 2003; Brew, 1999; Brew, 2001). The second position regarding the nature of research brings to mind the Humboldtian idea of Bildung. Bildung manifests a “community of learners” in the university where “the experienced professors and the inexperienced students participate”, “students become familiar with new findings” and all kinds of teaching activity aim to support “students’ independent pursuit of understanding and knowledge, more than means of transmitting or imparting knowledge” (Dysthe and Webler, 2010).

Besides the holistic underpinnings of research emphasized above, there are differences in approaches that stem from diverse disciplinary perspectives. The varying nature of disciplines and their distinctive conceptions of knowledge, the modes of effective teaching and learning in different disciplines, different forms of pedagogy and curricula all shape the ways in which research is conceptualized and practiced by members of different disciplines. As it is argued by Griffiths (Griffiths, 2004) the differences in the ways that “forms of inquiry can be integrated into student learning activities” derive from the existence of “a number of distinct “modes of knowledge production” or “ways of making knowledge” that are manifested in disciplines. There are “disciplinary spaces” that can be defined as “the environment associated with different disciplinary cultures in which research and teaching take place,” and these disciplinary spaces shape the ways that research, teaching and learning experiences interact (Healey, 2005).

Architectural education as a university-based professional education has its distinct ways of how knowledge is constructed within the educational process. The main goals of research in architectural education encompass the building of collective knowledge and advancement of educational quality by improving student learning. The process itself is as important as the product of research. This is related with the disciplinary nature of research in architecture.

In Charter for Architectural Research: A Declaration and a Framework on Architectural Research, prepared by EAAE- Research Committee in September 2011, architectural research is defined as the “original investigation undertaken in order to generate knowledge, insights and understanding based on competencies, methods and tools proper to the discipline of architecture.” In this declaration emphasis is placed on direct and indirect support of architectural research to education through “research training of future architects” as well as “the continual advancement of the discipline”:

“... The aim of architectural higher education is to develop a research disposition in students. As future architects they need to be able to establish basic premises, perform critical analysis, conduct intensive research and propose syntheses independently. The architectural school as a whole and the design studio in particular are places for research practice par excellence”

(Charter for Architectural Research, 2011).

In reconsidering architectural education as a project, emphasis is placed on the nature of project as a process. This process brings together cognition and experience, thought and action. Architectural education should be designed as a process composed of interrelated
phases that help generate an interaction between the subject and the object. Jean-Pierre Boutinet (Boutinet, 1990) uses the term project as "an educational process summoning the individual’s potential and motivations." Architectural education is a “project” in the sense Boutinet uses the term. The educational merits of this project stems from its potential to cultivate and improve intellectual and experiential knowledge, skills and attitudes of both teachers and students as interrelated actors of this process. What is at issue is not knowledge and understanding for their own sake. Construction of knowledge intertwines with the formation of different ways of teaching and learning. The enmeshing of knowledge produced through varying experiences of teaching and learning leads to novelty. In this way, architectural pedagogy becomes a continuous search and readjustment.

TEACHING-LEARNING-RESEARCH NEXUS IN ARCHITECTURAL EDUCATION

Teaching as an act of constructing knowledge through an interaction between the teacher and the student is the prevalent pedagogical approach in architectural education. This occurs as a dialogical process in which the role of the student is not that of a passive receiver, but of an active participant. The teacher acts as a tutor or mentor responsible for generating effective strategies and environments for learning. In order to achieve this, teachers should reflect on their own learning experiences. They should design the instructing process in a way to improve their teaching capacity, since teaching itself needs practice. In this way the act of teaching becomes an act of research that paves the way for new experiences of learning.

In the literature, numerous studies address different conceptions of teaching that derive from different conceptions of knowledge. A notable dichotomy stems from two opposite approaches to teaching: an “information transmission/teacher focused” approach to teaching versus a “conceptual change/student focused” approach to teaching (Trigwell and Prosser, 1996; Brew, 2003). While the first approach is based on a conception of knowledge as “objective and separate from knowers”, the second approach signifies the idea that “knowledge is more likely to be a process of construction” (Brew, 2003). According to an “information transmission/teacher focused” approach to teaching, research is a form of knowledge generation and teaching is a way of transmitting the knowledge generated through research. This understanding degrades the roles of both teachers and students. Teachers are portrayed as transmitters of pre-existing knowledge, while students become passive and homogeneous subjects ready to receive that knowledge. On the other hand, both teachers and students are attributed more active roles in the “conceptual change/student focused” approach to teaching. This approach is made apparent in pedagogical orientations such as critical pedagogy or transformative pedagogy. As noted by Ashraf Salama (Salama, 2009) critical pedagogy encourages the construction of new knowledge “through the dialogical process of learning” in which “the experiences of both students and teachers” are constructive. In a similar vein, transformative pedagogy supports “critical inquiry and knowledge acquisition, assimilation, and production in a manner that encourages students and educators to critically examine traditional assumptions and to encounter social and environmental issues” (Salama, 2009). Commitment to creativity, innovation, and continuous learning is the grounding principle of teaching both in critical pedagogy and transformative pedagogy. What is evident both in critical pedagogy and transformative pedagogy is a cyclical process in which critical inquiry leads to new understandings, new understandings lead to new experiences paving the way for new learning. In this way learning becomes a process of continuous development both for teachers and students as learners.
The prevalent approach to learning that informs both critical pedagogy and transformative pedagogy is “inquiry-based learning.” Learning by doing, experience-based learning, active learning and collaborative learning are all activities involved in inquiry-based learning. Involvement is for all modes of learning; the involvement of the student in the learning process that is also a research process. This involvement results in “acquiring skills and attitudes that permit students to seek resolutions to questions and issues while they construct new knowledge” (Salama, 2009). It is not only the student but also the teacher who is involved in this learning process. In the words of Le Heron (2004), both the teacher and the student become “co-learners” in inquiry-based learning processes. All these discussions can be re-contextualized into the older tradition of experiential learning raised in the seminal works of Dewey, Lewin, and Piaget, for whom “learning is most effective, most likely to lead to behavioral change, when it begins with experience, and specifically problematic experience” (Osterman and Kottkamp, 1993).

There are diverse forms of learning in architectural education that varies from theoretical learning to hands-on experience, as it is revealed mainly in the architectural design studio. An architectural design studio, portraying the particularity of design education, offers an integrative learning environment in which students encounter the technical, aesthetic, economic, social, or cultural aspects of architecture through a design problem generated from real-world problems. This environment encourages students to develop creative and reflective habits of thought and action. Informed by a student-centered pedagogical approach, the design project heads collaborative learning experiences as well as individual learning. It is this inquiry-based, active, experiential and reflective nature of design education that underpins Donald Schön’s argument of architectural learning as a “reflective practice” (Schön, 1983, 1987). Schön criticizes the persistent approach in technical rationality that depends on the idea that students learns a “body of theoretical knowledge...” and subsequently, that practice was “...the application of this knowledge in repeated and predictable ways to achieve defined ends” (Usher, 1997). The criticism raised by Schön seems highly relevant for architectural education in which theory and practice, knowing and doing can hardly be dissociated from each other. There is no one-way relationality between theory and practice in architecture. The idea that theory is the basis of practice, and that practice uses the theory produced apart from, it falls short of understanding the nature of the cyclical processes of knowledge generation in architecture. Architecture as a form of “praxis” entails the active engagement of the subject into the processes of all kinds of architectural creation, let it be in educational settings or in professional practice (Koutsoumpos, 2007a; Koutsoumpos, 2007b). These characteristics of knowledge generation are apparent in the processes of architectural education as well.

Architectural education, as a form of professional education, can be defined as a praxis in which thought enmeshes with action. Architectural education as praxis generates theory-in-action. We continuously learn architecture by doing it, by designing; furthermore we learn how to teach architecture by teaching. The learning environments in architectural education support students’ encounter with real-world problems, experiences of experiential and engaged learning. They also stimulate a dialogical and participatory relationship between teacher and student. For the teacher who acts also a learner, teaching architecture becomes a process of continuous learning. It is essential to create learning environments that build knowledge and reflective experiences both for students and teachers. Both parties have more active roles and the responsibility for the success of learning. In the words of Karen Osterman and Robert Kottkamp (1993), “each of whom brings knowledge and expertise to the situation—become collaborators working on a shared task.”
CONCLUSIVE REMARKS: SCHOLARSHIP AS A GROUNDING PRINCIPLE FOR RESEARCH-BASED TEACHING

The literature on the notion of scholarship should be addressed as a fertile ground for the debates on the interconnectedness of research and teaching in architectural education. The seminal work of Ernest L. Boyer at the Carnegie Foundation for the Advancement of Teaching opens new avenues for the discussion. In his report Scholarship Reconsidered: Priorities of the Professoriate (1990) Boyer underscores “teaching” as one of the four areas of scholarship in higher education along with “discovery”, “application”, and “integration.” This report not only challenges the “accepted hierarchy of research, teaching and service in the academy,” but also calls for a reconsideration of the scholarship of teaching that recognizes and rewards the “efforts to establish critical and rigorous cultures of teaching, and student support within the academy for the enrichment of learning communities” (Holgate and Sara, 2013).

As underlined by Boyer, teaching is a scholarly activity. Teaching becomes a scholarly activity when it is well designed as a process open to critical re-evaluation and development. Teaching should encourage students to develop creative and critical thinking skills by supporting active and experiential learning. Teaching practiced as a research process opens the possibilities of the teacher to reflect on his/her own experiences. Teaching as such moves from the transmission of knowledge towards the construction of new knowledge through reflective learning. This necessitates a change in understanding regarding the traditional hierarchy between the teacher and the student. The scholarly teacher, consistent with Boyer’s definition, is eager for lifelong learning. This understanding of scholarship of teaching calls attention to “critical inquiry into how student learning can be promoted, both in generic terms [i.e. general educational principles] and in relation to particular subject fields” (Griffiths, 2004). There is a need for architectural education to place greater emphasis on pedagogies that integrate research and teaching as modes of active learning, both for teachers and students.

Accordingly, teaching as a scholarly activity promotes bringing together of learning and research as an academic attitude and ethical gesture. At this point, once again reference should be made to Boyer’s conception of scholarship signifying a sense of community. Boyer insists on academic communities of practice as the grounding principle of scholarship. Being a community necessitates the presence and active participation of all members of academic departments, or disciplines - the students, academics and also professionals. These participants should be engaged in critical inquiry of the known and established, and be open to unplanned and beyond the established. Consequently, teaching and research comes together on the basis of critical scrutiny that leads to learning. This in turn fosters personal growth and development.

As research-based teaching is redefined to include the forms of knowledge generation that stem from inquiry-based and experiential learning activities, developing a framework for knowledge generation through teaching architecture becomes a significant contribution. Research-based teaching has the potential to generate learning experiences through which we, as teachers, learners and researchers, can make contribution for the enhancement of the discipline of architecture.

REFERENCES


INTRODUCTION

Developing technologies, such as computational design and digital fabrication, are transforming the design and construction of contemporary architecture. Today, architecture schools are tasked with introducing digital technologies as they are changing, creating an opportunity to develop innovative curricula and democratize access to these skills. However, the understanding of how to teach digital technology as an essential design skill has not kept pace with these rapid changes. Design education and digital technology education continue to be seen as separate loci of learning, separated by pedagogical gaps and teaching mindsets.

The aims of this paper are to take control of the pedagogical agenda for digital design in architectural education by debunking the myth of the digital native and to apply proven educational research to the pursuit of digital design. Two pedagogical proposals are put forward: learning objectives and soft skills for digital design in architecture. To be clear, this paper is a discussion of architecture, design, and education; not an argument for software and computer use in design. The relevance of this educational conversation extends only so far as it impacts the development of the profession’s relationship to digital technologies as these technologies are changing. The goal of this, and any, educational proposal for architecture must be improving the state of architectural design in addition to advancing learning in both the academy and the profession.

Much of architectural education today is what Bruner calls “folk pedagogy”, guided by implicit assumptions but not connected with educational theory or evidence beyond one’s experiences (Bruner, 1996). This places the architectural discipline in an unfortunate position where it neither benefits from nor makes contributions to the larger conversations occurring in educational research. In the past three decades, advances in cognitive learning theory and psychology, supported by empirical evidence collected from rigorous classroom assessment, have brought science into the art of teaching. This paper applies principles from educational research to improve digital design instruction by bridging the gaps between studio learning and technology (digital) learning. The first section of this paper describes learning objectives and Bloom’s
Taxonomy as tools of educational research designed to create clarity, transparency, and accountability among educators. Articulating learning objectives that are specific to digital design in architecture frames a conversation as to why there is such inconsistency and disagreement about the requirements of digital education across architectural curricula. The use of learning objectives may seem obvious or unnecessary if one is only considering their use in one’s own syllabi, but in terms of disciplinary alignment, digital design instruction could benefit from the additional clarity offered.

The second section of this paper describes a list of soft skills that support students as they learn digital design followed by several methods for integrating soft skills into digital design instruction. Soft skills are “soft” in contrast to more easily quantifiable “hard” skills such as operating a machine or knowledge of art history. Failure to acquire soft skills such as resourcefulness, good electronic communication etc. negatively impacts how technology is introduced, practiced, and developed in architectural studio culture. With the rapid pace of technological change, students need to be comfortable with and capable of learning, relearning, and integrating new programs and tools throughout their career. Soft skills provide a framework for helping students develop this mindset and facility.

BETWEEN DESIGN AND DIGITAL

Computer-Aided Drafting and Design (CADD) technologies have become commonplace in architectural practice as tools of efficiency and production. For these very reasons the introduction of CADD in early architectural curricula has been fraught with anxieties along a continuum: from the undoing of creativity through positivist and reductionist logic (Pullasmaa, 1996) to a firm belief that these technologies will revolutionize the way architects practice and think about design (Kieran and Timberlake, 2003). At the same time, there is a presumption that students who have grown up with digital technologies are “digital natives” who possess special aptitudes or insights which are disruptive to learning computing. The presence of these anxieties and biases often leads to gaps in architectural pedagogy, as digital tools are misunderstood and misappropriated by students and teachers alike.

Digital design is a term in common use, however its definition is unclear. One the one hand, there is very little architectural work today which does not use the computer in some capacity, and yet there are also designs which consciously engage in digital aesthetics and processes. The latter is obviously digital in aesthetic, but the former could still be considered digital by method. The very existence of the category of digital design is problematic because it implies two cultural silos in architecture: those who are digital and those who are not. This outlook potentially limits students’ educational and professional development.

Design is the verb in architectural education and in architecture; it is what architects do. For the purposes of this paper, digital design refers to the use of the computer and computer-driven tools (such as CNC machines, robots, etc.) when one designs architecture. The key is not what a person designs, rather whether that person employs the computer or not as a tool in architectural work. This paper interprets digital design as a broad skillset that should be available to all students, rather than
a niche specialization.

It is necessary to create the distinction between design and digital design – and to speak of teaching digital design – in this moment, because the introduction of the computer in architecture changes both what and how architects design. It introduces both new capabilities and new sources of bias and error. Therefore, it is necessary for architectural education to address and teach specific ways of designing with the computer – not how to use software or operate machines, but how to design digitally.

THE MYTH OF THE DIGITAL NATIVE

The common belief that students are self-regulating when it comes to learning and using technology may come from the notion of digital natives. The label “digital native” derives from a series of articles written by the technologist Marc Prensky during the early 2000s. Prensky describes the generation of young people born since 1980 as “digital natives” due to what he perceives as an innate confidence in using new technologies such as the internet, videogames, mobile telephones and “all the other toys and tools of the digital age”(Prensky, 2011). Enrique Dans counters Prensky’s claims: “Simply being born into the internet age does not endow one with special powers. Learning how to use technology properly requires learning and training, regardless of one’s age.” Dans goes on to expand upon the issues of assuming students do not need to be taught to use technology thereby becoming “digital orphans”, lacking in any model to copy or experiences that might have generated criteria for understanding (Dans, 2014).

For this reason, beyond basic fluency, architectural instructors are uniquely positioned to model substantive content creation and healthy critical thinking about these technologies. By perpetuating the myth of the digital native, architectural education is missing the opportunity to establish strong pedagogical foundations from which future digital advancements will emerge.

PEDAGOGICAL ALIGNMENT AND THE VALUE OF DIGITAL DESIGN

The lack of agreement and clarity among schools regarding digital design creates problems for the discipline. How can a skillset be taught without a clear definition? And how can the field evolve when there is such contention over education in a critical area? Dialog and common ground are needed.

A key reason for the confusion surrounding digital design instruction in the university setting is a misunderstanding of its educational value as a set of skills beyond technical skillling. One of the most significant changes made by educational research has been to redefine the goals of learning. Decades ago, before the development of contemporary learning theories, schools emphasized developing core skills such as reading and memorizing information such as dates and facts in a history class. The implicit assumption was that this level of learning was sufficient for students to write reports, solve problems, and produce other sophisticated applications of literacy. However, while many students could demonstrate ability at, for instance, providing the correct solution for a specific type of word problem, educational researchers found that students rarely understood what they had learned, nor could they easily apply their skills and strategies to new contexts (Clement, 1982). The students knew
their lessons by rote and adapted to succeed at their instructor’s tests, but they had a superficial understanding of the material. Today however, educational models and expectations have evolved, digital technology is often relegated to this type of learning.

While skills and facts remain important to learn, the goal of education today has been restated: to provide students with a foundation of deep learning and the intellectual tools to ask and address meaningful questions. (Bransford, Brown, and Cocking, 1999) In contrast to superficial learning of facts and procedures, deep learning entails knowledge of the underlying principles, domain structure, and strategies to activate skills and knowledge and apply them flexibly in a variety of conditions – particularly conditions which are different from the ones where learning originally occurred, such as the translation of design thinking from an academic to professional context. Deep learning is what most instructors would recognize as productive and transferable learning, yet few courses actually achieve. Architectural studios are examples of a deep learning environment.

In contrast to architectural studios, the current state of digital design instruction in architecture tends to follow an educational model which does not support deep learning. Presently, much of what students learn is by rote: sequences of commands and procedures intended to produce reliable results. While students can operate software and other tools with what appears to be great fluency, the vast majority do not have a deep understanding of computing or digital media principles (Senske, 2014). As a result, their work tends to be inefficient and derivative. Like the school teachers in the earlier example, digital design instructors emphasize core skills for using digital tools and then expect students to apply them towards design projects. This is the reason a learning gap exists. First, students do not learn the tools with significant guidance to develop depth and rigour; second, they are not taught explicit strategies for applying digital methods to design tasks. Students often fail to develop an understanding of digital design methods because the pedagogy is not aligned with the goal of deep learning. This leads to a frequently cited criticism of digital design: work which is repetitive or derivative because students are grappling with technology rather than controlling it. The technology does not make it this way – it is how it is used.

This is assuming such a goal is recognized in the first place. Learning digital tools is often seen – by students and faculty alike – as mere technical skilling rather than a way of thinking about design. Professional architectural accreditation (NAAB) in American schools uses a set of learning criteria which specify Ability and Understanding (NAAB, 2014). However, this set of criteria does not address digital design with any specificity. There is no agreement upon the value or content of a digital design education, and so student abilities can vary widely from school to school, and within academic units. Students are less inclined to develop a thorough knowledge of digital design because it is not universally considered a meaningful intellectual and creative pursuit. This not only hinders progress within the discipline, but, in practical terms, it affects the profession. Failure to recognize the principles of digital tools and structures of problems they address makes it more difficult for students to learn and retrain themselves in response to changing technology.
The educational model of the design studio is unique in its approach because it has many elements which contribute to the production of deep learning, such as opportunities for synthetic learning, active learning, complex problem solving, and self-reflection and critique. This is precisely the kind of approach that would benefit digital design education. Unfortunately, the architectural design studio is often seen as one type of learning, while digital design, which is thought of as mere technology, is seen as another. This disconnection is due to a misunderstanding about digital design due to a lack of clearly-defined and shared pedagogical goals. The present situation in education has come about because the implied goal of digital design education is mere tool operation (which does not require deep learning) when the expected outcome should be increased agency and sophistication of design ability. One way to address the problem of pedagogical misalignment is to develop learning objectives for digital design. Learning objectives have the benefit of being a structured, well-understood, and research-based approach to curricular development. This method informs clarity and represents an explicit way to connect the goal of deep learning with pedagogical execution.

BLOOM'S TAXONOMY

A useful tool for developing better learning objectives is Bloom's taxonomy. The taxonomy is a hierarchical framework intended to help instructors coordinate their planning and assessment using a common language (Krathwohl, 2002). It represents the process of learning from acquiring simpler to more sophisticated thinking skills. The general idea of Bloom's taxonomy is that lower levels of cognition support higher levels. For instance, one must understand the difference between different methods of constructing a surface (comprehending) before choosing which surface to use (applying).

In its revised form, Bloom's taxonomy lists six levels of cognitive processes:

1. **Knowing**: memorization and factual recall
2. **Comprehending**: understanding the meaning of facts and information
3. **Applying**: selection and correct use of facts, rules, or ideas
4. **Analyzing**: breaking down information into component parts
5. **Evaluating**: judging or forming an opinion about the information
6. **Creating**: combination of facts, ideas, or information to make a new whole

A more recent addition to the discussion of the taxonomy is the inclusion of types of knowledge. Anderson and Krathwohl addressed criticisms of the taxonomy by recognizing that not all knowledge is equal in complexity and that knowledge tends to be developed from concrete (facts and concepts) to abstract (procedural) and finally to knowledge of one’s own cognition (metacognitive) (Anderson and Krathwohl, 2001). In concert with cognitive processes, the knowledge dimension of the revised taxonomy enables a more nuanced discussion of learning objectives. For instance, under the newer version, the taxonomy does not progress and stop with creating, but also includes thinking about one’s learning progress and how one creates.

Bloom’s taxonomy has been criticized because it does not represent the complex and interconnected nature of cognition (Furst, 1981), but the taxonomy was never conceived of as a model or theory. Nor is it a prescription for every course to follow. One could design a course with at least one learning objective at each level. Depending
upon the skills required, some levels may need additional objectives. Students with different abilities may be able to begin learning at higher levels. The value of the taxonomy is less that it represents exactly how learning works or that it tells instructors how to teach, but rather in how it helps to organize and align pedagogical thinking. Educational frameworks like Bloom’s taxonomy are not in common use in architectural education. The reason for this is unclear but may derive from a disciplinary resistance to self-articulation. However, for those developing or revising architectural curricula, having access to a set of learning objectives that uses the taxonomy can enable a dialog within the discipline, with other disciplines and educational researchers.

Bloom’s taxonomy helps support the goal of developing deep understanding in digital design instruction. One way it accomplishes this is by establishing the basic cognitive processes involved in learning to design thoughtfully. To see all of these steps organized and consider them with respect to digital design is to shed light on what is often an opaque practice. The taxonomy makes it clear that one does not just use or not use various tools, but one must understand them, choose from them, and evaluate those choices as part of a design process. In this manner, an advantage of learning objectives developed through Bloom’s taxonomy is that they can elevate student outcomes towards higher-order thinking (Biggs, 1999). For example, without the proper outcomes articulated, a student might submit a design, but by merely applying a procedure. Bloom’s taxonomy makes it clear that creation depends as much on understanding one’s decisions (the “why”) as knowing the correct commands (the “how” – which is often students’ focus). For teachers and students alike, Bloom’s taxonomy helps clarify that the goal of digital design instruction is not only to learn how to use digital tools, but to apply them towards better designs and more sophisticated design thinking.

With regards to teaching methodology, the clarity of learning objectives derived from Bloom’s taxonomy can help motivate qualities of student performance which are often lacking in digital design courses, such as innovative solutions and well-crafted, thoughtful representation. As mentioned in the previous section, many learning objectives are not specific enough, sufficiently measurable, or targeted to student’s learning level. Bloom’s taxonomy can help ensure that students are practicing the skills that they should be learning in their activities and at an appropriate level of cognition. This enables the pedagogical gap between learning digital methods and creating designs to be filled with deliberate (or mindful) practice.

Deliberate practice is a recognized process through which individuals train themselves to high levels of performance. Research has shown that learning of complex skills is most effective when students engage with tasks that are appropriately challenging, with clear performance goals and feedback, and sufficiently frequent opportunities for practice (Ericsson, Krampe, and Tesch-Römer, 1993). The difference between merely making and deliberate practice is that a student monitors their progress towards a specific goal and changes their performance in response to feedback. The student continues to do so while increasing the challenge of the activity to further improve. Learning objectives assist students in deliberate practice by creating specific and appropriate performance goals which they can use to monitor their progress. This guidance directly supports the development of abilities on the highest (metacognitive)
level of the taxonomy, which are crucial for sophisticated work and achieving transfer of skills and knowledge to other domains (Perkins and Salomon, 1992). Thus, the notion of deliberate practice stands in contrast to the disengaged ways that many students learn and use digital tools, which is often oriented towards production for its own sake rather than for quality or thoughtfulness. Introducing deliberate practice is one way for schools to motivate deep understanding and to bring craft back into discussions about digital representation.

**LEARNING OBJECTIVES FOR DIGITAL DESIGN**

The idea of a learning objective is straightforward, but often misunderstood and misapplied. A learning objective is a specific statement which describes what a student will know (knowledge) be able to do (skills) as a result of engaging in a learning activity. A learning objective must have three parts: a measurable verb associated with the intended cognitive process, the necessary condition (if any) under which the performance is to occur, and the criteria for measuring acceptable performance (this is often implied). A simplistic example of a learning objective that fits this pattern is: “Given a set of contours the student will be able to generate a topographic model.” The
condition is having a set of contours and the implied measurement is an acceptable model. Learning objectives are focused solely on student outcomes and do not specify methods or other expectations for the teacher. They are not an attempt to create uniform classroom procedures or hinder instructor creativity through standardization. The teacher has flexibility in their approach, so long as the performance criteria are met. Learning objectives are useful because they help instructors with course planning and the creation of content. Furthermore, the explicitness of properly-constructed learning objectives establishes a basis for student assessment as well as the evaluation of teaching and curricula (Anderson, 2002). A primary challenge of digital architecture evaluation is the lack of criteria and therefore a lack of agreed-upon traits for which to evaluate whether digitally produced code, drawings or images are successful.

In this manner, learning objectives support better learning and provide a common framework for schools to organize their efforts at improving education. For this reason, many universities have standardized their syllabus policies to address learning objectives [see (Vanderbilt, 2016) and (Carnegie Mellon, 2016) for example]. The use of learning objectives may seem obvious or unnecessary if one is only considering their use in one’s own syllabi, but in terms of disciplinary alignment, digital design instruction could benefit from the additional clarity offered.

The real issue is not that learning objectives do not exist for digital design courses, but rather that they are not often used correctly, in response to the findings of educational research. First, many stated learning objectives do not take into account the learning process for developing complex skills and thinking. As mentioned earlier, traditional digital design pedagogy tends to emphasize learning through design tasks. The tacit learning objective of most activities, ostensibly, is to design something via digital methods. However, this does not acknowledge the steps involved to prepare students for design, such as learning about the tools, practicing methods, comparing and selecting methods, etc. These skills and knowledge are implied by the goal of designing, but by not stating this explicitly, the instructor might neglect teaching and assessing the constituent skills and knowledge that students need, but might not manage to learn on their own.

When developing learning objectives, it is important for digital design instructors to acknowledge how learning occurs as a developmental process. Creativity and autonomy, abilities exercised in design work, are higher order thinking skills. Higher order thinking is dependent upon requisite technical skills and other cognitive resources (Weiss, 2003). As such, these activities may not be beneficial learning experiences for beginner and intermediate students. Research shows the importance of matching learning objectives to student level (Klahr and Nigram, 2004). Novices benefit from direct guidance in basic skills and knowledge, while objectives for advanced students should emphasize synthesis and independence.

Second, many learning objectives for digital design instruction conflate activities and goals with learning outcomes. A goal is a statement of the overall intended outcome of a learning activity or course. Learning objectives are specific achievements which contribute to the goal (Ferguson, 1998). For example, a course description that says “students will be exposed to digital fabrication technologies” has presented
a goal, but not stated a specific, measurable outcome. Likewise, a statement such as “students will fabricate a small-scale physical model” describes an activity, but does not provide enough information to discern what students are supposed to learn from the activity. A learning objective that addresses these issues would be: “students will use GIS data to generate a small-scale physical model using appropriate digital fabrication techniques.” This objective presents a condition (GIS data), an outcome (the model), and assessment criteria (are the techniques appropriate? / is the model is correct?). Understanding the learning objective helps define the cognitive skill level of the activity and the appropriate assessment. For instance, if the objective was to learn about computing concepts, issuing a quiz with questions about procedures would not be a helpful measurement. To facilitate effective instruction, goals, activities, and learning objectives must be aligned with one another.

Last, many learning objectives as presented do not support a means of formative assessment. Most courses only assign grades for projects, which are typically creative or design work. Again, these are higher order thinking skills and may not be appropriate to assess from novices. Grading project submissions does not give the instructor or the student much opportunity to remediate skills or knowledge that were misunderstood or not acquired. Moreover, feedback on a design artifact may not help instructors and students achieve the goal of deep understanding because it makes conceptual and procedural knowledge indistinguishable from the outcome. Studies have shown that ability to perform procedural tasks does not mean students are able to explain what they are doing or why (Schoenfeld, 1985). This is not to say that instructors should never grade projects. This is appropriate when the intent is to assess creative work and problem solving, particularly from an advanced class. Learning objectives should measure the correct student outcomes for the level of the student and in a manner that allows students to respond with changes in their performance.

SOFT SKILLS AND FOSTERING LEARNING HABITS
The development of rigorous learning objectives is the first part of creating a learning environment for digital design. The second proposal of this paper is to cultivate a
set of complementary “soft” skills which are currently missing in most digital design instruction. Computer use in architecture is often discussed and taught as a series of technical or “hard (as in absolute)” skills. In contrast, “soft” skills are related to emotional intelligence, attitudes, habits, and interpersonal relationships. An example of a soft skill is resourcefulness: being inclined and able to find alternate solutions to a problem, rather than giving up or deferring responsibility. In this manner, soft skills influence the ways that an individual applies technical skills to achieve goals, such as a design. Learning soft skills has been related to improved employment outlook and better job performance (Andrews and Higson, 2008; Nealy, 2005). Professions such as business and information services have cited employees’ lack of soft skills as one of the primary reasons why projects fail (Bancino and Zevalkink, 2007). Thus, for students, developing soft skills is equally as important, if not more important, than learning technical skills. This is because soft skills can be reapplied to changing technology, whereas hard skills may fall away as technology changes.

The influential Boyer report on architectural education concluded that: “[A]rchitectural education is really about fostering the learning habits needed for the discovery, integration, application, and sharing of knowledge over a lifetime” (Boyer, 1996). Soft skills are the learning habits Boyer references and as such must be taught rather assumed to be pre-existing skills. This also extends to those soft skills which relate to digital design in architecture. Hereafter, ‘digital tools’ refers to software programs, computing devices such as laptops, tablets, etc., fabrication systems (laser cutters, 3d printers, CNC machines, etc.), robots, embedded systems, and anything else that involves computers.

Architectural education must recognize that university students are not comprehensively or consistently trained in digital technologies when they arrive on campus. This is exacerbated when less privileged students are potentially less digitally skilled than students from economically privileged backgrounds. By not addressing these inequalities, institutions such as architecture schools are perpetuating disparities through education.

TRADITIONAL VS. DIGITAL SOFT SKILLS

The type of soft skills described in this paper are not entirely the same as soft skills introduced in the previous section. While traditional soft skills such as conscientiousness and empathy are helpful for architects, digital soft skills have a different purpose and apply specifically to the tools and processes used in digital design. Digital soft skills, such as asking clear questions, estimation, and planning skills, enable effective collaboration with other people while using digital tools and promoting effective workflows for collections of digital tools. Digital soft skills support students as they are learning digital design and, later, help students apply technical skills successfully and with sophistication and to adapt to a rapidly changing technologic landscape. Digital soft skills also differ from traditional soft skills because they take into account the particular challenges of computing and digital machinery. The special attributes of digital tools that make them powerful, such as symbolic logic, abstraction, and automation, can invite cognitive biases when designers operate those tools simplistically, at face-value (i.e. using a computer like a cell phone, a pencil, or a typewriter). Humans must adapt their thinking, expectations, and habits, as their
natural inclinations can interfere with working effectively with digital tools (Sheil, 1983). Even those who work with digital tools frequently need to learn digital soft skills, as they may have developed bad habits and misconceptions over time. Merely using digital tools is not enough to cultivate mindfulness of the medium and one’s responses to it.

To cite an example: digital tools are often “black boxes” with complex layers of interrelated procedures that make it difficult for users to be aware of what they are doing and how their software operates. Users expect simple cause-and-effect relationships between their operations and the results on a screen, when the reality is that many “hidden” processes are at work and can affect the outcome of an interaction (Blackwell, 2002). This is also one reason why computers are not always dependable and why they tend to break down in obscure and obtuse ways. Working responsibly with digital tools requires a certain level of comfort and responsiveness with an opaque tool. Students who lack the digital soft skills to understand and respond to this condition often have a poor attitude when faced with computer problems and may spend their time in unproductive ways trying to “hack” solutions to technical
problems (Pea, 1987). This affects not only the quality of their final designs, but their outlook on technology in general. Digital soft skills are similar to traditional soft skills in the way they affect how students apply technical skills. They are the bridge across the gap that often exists between design skills and technical (hard) skills like digital methodologies. Unfortunately, very little time, if any, is given in architectural curricula to the explicit cultivation of digital soft skills.

SAMPLES OF DIGITAL SOFT SKILLS

The following list is a representative sample of digital soft skills which could be taught in an architectural curriculum, organized according to four primary headings.

Communications Skills
Communicating clearly with others is a critical set of soft skills for architects, particularly when using digital tools. For instance, many students have never been explicitly taught how to ask a question via email: to provide necessary information and files upfront, anticipate follow-up questions, and to communicate their expectations for resolution. This is important not only professionally, but especially when trying to learn or fix something like a new piece of software.

Collaboration - The ability to work with others digitally, particularly at a distance. One aspect of this is organizing files and sharing them across computing platforms and software versions.

Authorship - This is the ability to understand digital intellectual property and to distinguish between resourcefulness and plagiarism. This notion of authorship becomes increasingly important when the line between programmer and designer is blurred by the use of digital tools. Of particular note is the downloading of code or Grasshopper definitions which are then deployed as design generators.

Support - Architects should be able to seek, locate, and pursue support for software and technical issues, many of which might exceed the abilities of the instructor or the support offered by an academic institution. These skills include asking fellow students, contacting the software maker directly, and using the Internet as a resource.

Adaptability
Adaptability is resiliency in response to imperfect tools and a field constantly in change. Digital designers should work with the understanding that failures are to be expected, while being empowered to seek alternatives. They must also update their skills and abilities often while remaining critical users of technology.

Autodidacticism - The ability and inclination to teach oneself (quickly) is a valuable skill for designers. This includes planning and scheduling regular time to learn and a recognition of common concepts and methods shared between tools, which can make learning more efficient.

Conversion - An effective strategy for error recovery is knowing how to share data several between types of files and programs. It is important to also note that many computer programs are able to convert various file formats and
often have similar procedures.

**Time Management**

Digital design projects in architecture are often complex, involving many different programs and machines, as well as human team members. Some of these elements can be hands-off (such as rendering) or very hands-on (supervising CNC fabrication). Part of completing them successfully is knowing the workflows involved and having a sense of their coordination and time requirements.

*Estimation* - There is a common misconception that technology makes design faster and easier. It takes experience and skill to determine the full amount of time needed to complete a digital task or processes (e.g. milling, printing, rendering).

*Sourcing* - The ability to identify the most effective tool and process for the development of the idea and in relation to the time available for production. This requires understanding the different elements of digital production such as the difference between a raster and a vector.

*Preparation* - Plan for contingencies and alternatives. Assume some things will inevitably not go as expected and know the options available.

*Scheduling* - Develop internal deadlines, realistic calendars, and skills for planning and implementing a multi-step process. For instance: development of a digital file for fabrication, then fabrication, then post-production.

**Digital hygiene**

Digital hygiene refers to the good habits of caring for equipment, computer hardware and software as well as preventing and recovering from errors.

*Organization* - Maintain files in a structure which is both navigable and searchable by users.

*Backups* - Create a backup routine that is an embedded part of the digital process (cloud, physical media, & storage). This also includes knowledge and use of software auto-backup and recovery. Keep at least one physical backup off-site.

*Clean-up* – Regularly sort, store, and purge project files to manage storage and make important files easier to locate.

**TEACHING DIGITAL SOFT SKILLS**

Many of the examples listed under soft skills can be classified as character or personality traits. Successful students may already practice soft skills and therefore it is often assumed that these are character traits rather than teachable attributes. One might wonder, given the age of many college students, if such habits can be changed. However, the very notion of “soft skills” implies that these behaviors and habits can be taught to students. There is evidence to support the idea that, with training, young adult students can learn new traits and learning strategies (Perkins, 1989).

Another common argument is that soft skills are best learned in the workplace. While the workplace presents an authentic context, it does not offer the same opportunities for focused learning as design school. Moreover, one of the reasons for learning soft
skills is to make one more competitive in finding employment. Students should have a sense of how these skills translate into practice before they enter the market.

How can schools teach digital soft skills? Merely lecturing to students about them is not an effective strategy. While lectures can be helpful for delivering information or persuading an audience, changing and developing habits requires more engagement. The method of training varies depending upon the attribute and the audience, however, generally-speaking, habits of learning can be developed through a process of investment and practice.

Supporting a new habit which a student does not create themselves requires helping them understand its meaningfulness. It can be easy to dismiss soft skills out of hand because they might seem to be obvious or less interesting than learning technical skills. For this reason, it is important for the instructor to communicate why new strategies and habits are helpful (McCombs, 1996). Investment begins by identifying the soft skills in question and explaining to students the value of the skills within design and production workflows. To be most effective, those values should be immediate and goal-oriented. Although it is true that developing soft skills can help a student get a job in the future, explaining to a student (for example) that organizing their files saves them time and reduces errors on their current project is less abstract and applies to their current situation. Helping students understand the gaps in their present abilities and how learning soft skills can help close those gaps is the first step toward effective habituation.

To be most effective, teaching soft skills should be integrated with hard skills teaching and preferably in the context of a project (White and Frederickson, 1998). It is not necessary to revamp an entire course around soft skills. An instructor can introduce them where they naturally occur within design and production processes. For example using an error that students commonly encounter to introduce search, problem-solving, and communications skills. Relevant material like this helps focus student attention while a legitimate context helps them retain and access what they have learned later.

Demonstrations can be more effective when they are supported by teaching materials that help organize knowledge for students (Bransford, Brown, and Cocking, 1999). A simple check-list, for example, can help students remember how to organize a digital group project. Once students have mastered the soft skills involved, the student will not need the scaffolding provided by the list. However, if the student makes a mistake or needs to refresh their learning later, the list provides a useful reference and a prompt for activating digital soft skills. Externalizing implicit practices and helping students focus on relevant information and methods improves the effectiveness of soft skills teaching.

Delivering soft skills in class benefits from a coaching approach. Because the goal is to change student attitudes over time, rather than delivering information or procedures, a “one and done” demonstration is not an appropriate teaching style (Mistrell, 1989) (Bransford and Stein, 1984). With coaching, the instructor discusses the advantages of a skill (creating investment), then models the behavior while explaining to the student what they are doing and why. This last step is important because students
need to understand when to apply a skill as much as they need to know the technical operations involved (Scardamalia, Bereiter, and Steinbach, 1984) (Simon, 1978).

Next, students demonstrate the skill and receive feedback from the instructor on their performance. This is followed by more practice and feedback over time and in concert with other skills to approximate holistic design activities. The goal of coaching is to cultivate not just practice but deliberate practice over time – making the student aware of their own actions and motivating retention and refinement (Ericsson, Krampe, and Clemens, 1993). This creates deep and lasting learning.

Adopting a coaching style of instruction requires a change in how students are graded and given other feedback. Most assessment in studios and seminars is summative, meaning it measures the final outcome of a student’s work. This is suboptimal for shaping behaviors, as it does not measure the process sufficiently and is often too late to influence a student’s soft skills. Formative assessment techniques, which encourage personal reflection, timely feedback, and student response are useful support for the “coaching” (Vye et al., 1998). To supplement these techniques, instructors should not only observe student behaviors but review digital files, as well. Many courses emphasize the final artifact and never look at the files involved. Reviewing files is critical so the instructor can observe attributes such as organization, efficiency, and other procedural nuances.

Lastly, in order to properly cultivate habits, soft skills should be reinforced in the studio and lab even when they are not being formally taught. Instructors should be mindful and consistent in their own habits, demonstrating modeled behaviors in their personal actions. For example, an instructor’s demonstration files should be well-organized to set a good example for the students. Student interactions should also emphasize consistent behavior. If a student asks for help with a tool, for instance, the instructor should evaluate how the student asks questions and replay the scenario with them while making explicit the strategies involved. Learning should be embedded in the classroom experience. It must be a continuous practice, not merely an exercise.

DISCUSSION

The challenge of making claims about design pedagogy interventions, like soft skills, is proving their effectiveness. In educational research the difficulties of empirical measurement in traditional subjects like math and reading are well-known (Black and Wiliam, 1998; Shepard, 2000), but the challenges of demonstrating the impact of an intervention upon design outcomes – which are not easily measured or quantified – make this task even more burdensome and its conclusions unreliable. As such, there is no accepted model for proving the effectiveness of design pedagogy. What is more important and perhaps easier to ‘prove’ is that well-articulated digital soft skills create a framework and a platform where technology can be used expansively and in unique ways rather than reductively and repetitively. The value of digital soft skills is to suggest a replicable model which remains relevant and useful for students as technology changes, improves, and adapts.

With regards to learning objectives, their value is not what they add to a syllabus, but rather how they prompt a larger conversation about educational and professional
values and standards. Creating learning objectives for digital design in architecture exposes many implicit assumptions about what faculty believe about learning and the role of computing in the studio. At the same time, discussing learning objectives is a provocation towards architecture schools to consider digital design as more than merely learning to operate tools and software (activities which are not themselves valid learning objectives) and to instead connect these practices to design thinking and the development of architectural designs.

Bloom’s taxonomy assists in framing a more constructive discussion about learning to design digitally by offering a structure of cognitive accomplishments for students. This helps re-align architectural educators away from frameworks derived from folk pedagogy and towards established theories and research into educational psychology and learning cognition. Instead of teaching and learning digital skills and knowledge through a hierarchy of the tool’s features or increasing complexity, Bloom’s taxonomy foregrounds processes of remembering, thinking, and judgement. These objectives are more closely aligned with deeper understanding and integrative mastery. This type of learning is precisely the antidote to the kind of superficial engagement one often finds in architecture schools that prompts negativity towards the use of computing in design.

The purpose of reflecting upon learning objectives for digital design in architecture is not to produce a definitive list of what students ought to learn. Learning objectives are written for specific curricula, student needs, and faculty interests. They are useful because they provide a clear definition of expected outcomes and which becomes a point of dialogue. In order to evaluate something, it first must be named. Through evaluation and discussion, a discipline develops. When Bloom created the learning taxonomy, this was the goal. Not to explain or lay claim to how students must learn, but to provide a shared structure so educators could compare their approaches. In a similar manner, creating and sharing learning objectives for digital design instruction can produce a more organized dialogue about how to align the use of digital tools with the core values of architectural education and the development of the discipline itself. The development of a more coherent set of evaluation criteria in digital education will increase the rigor of conversations about the future of digital design in architecture. Learning objectives are not only for evaluating one’s students or teaching. They help departments and educators understand whether they are teaching the right things. The question should always be: “how does this improve design?”

CONCLUSION

While digital design skills are critical for 21st century designers, architectural education must also recognize and deliver more than technical proficiency. Working creatively and effectively with computers, digital fabrication machines, and other devices requires a new set of workflows and adaptations to academic and professional behaviours. Boyer’s report makes it clear that one of the key values of an architectural education is developing learning habits. A present gap in student learning is that traditional learning habits have not been updated in response to changes in technology (Boyer, 1996). Learning objectives and soft skills for digital design can help to bridge these gaps.
Incorporating learning objectives and soft skills into existing digital instruction may require more work from both the instructor and the students, but the benefits are lasting. Becoming more aware of one’s process and developing good digital habits pays off, no matter what software or tools one encounters. Ultimately, teaching learning objectives and soft-skills is about making students more independent and self-directed learners. With the rapid pace of technological change, students need to be comfortable with and capable of learning, relearning, and integrating new programs and tools throughout their career. For these reasons, learning objectives and soft skills can and should be implemented throughout digital design education.

Learning objects and soft skills support the goal of not only working well with technology, but together with other people in technologically-supported ways. Knowledge, abilities, attitudes, and habits not only shape one’s process, but one’s design goals and outcomes, as well. Soft-skills and learning objectives impact design and so they extend beyond pedagogical or semantic arguments. They should be of interest to anyone who values how technology supports good design.

REFERENCES


Material / tooling / prototyping: the production of full-scale models in architectural education

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ABSTRACT
This paper explores the use of the performative model in architectural education, specifically through a Design/Build learning method. It argues that the prototype, or the full-scale development of an operational model, is a valuable mechanism for students in gaining knowledge of material, fabrication and construction techniques through the act of making. By examining three case studies of Design/Build pavilions undertaken in the Emergent Technologies and Design Programme at the Architectural Association from 2012-2015, this paper aims to develop an approach to education where the final output is only a means to an end, but where learning originates from the process of production itself.

INTRODUCTION
The model in architecture has a long-standing yet ambiguous history. In Tools for Ideas: Introduction to Architectural Design, Christian Gainshirt (2007) suggests “the architectural model can be used for a large number of purposes, which makes it a highly effective, but also problematical design tool,” in that the model is used commonly as a representational tool although also has the capacity to operate performatively. With the innovation of computation and fabrication in architecture over the past twenty years or so, the potential of the model as a performative prototype has increased dramatically; leveraging this technology provides new opportunities via the act of production.

Through the investigation of three case studies of Design/Build projects undertaken by students in the Emergent Technologies and Design Master Programme at the Architectural Association School of Architecture from 2012 to 2015, this paper interrogates the full-scale model as a mechanism for architectural education. Carbon Curve, designed and built in 2012-2013 explores the development of a material technique capable of controlling curvature and structural stiffness through the application of a slotting pattern to plywood sheets. In Fingers Crossed, from 2013-2014, the study of fabrication tolerances provides an opportunity for the development of a pavilion that solely employs friction joints, avoiding the use of any metal connections. Finally, The TWIST, designed and built in 2014-2015, interrogates the numerous issues around designing a cantilevered geometry with a complex construction process.
In all three examples, it is the production of the prototype that provides opportunities for learning. While computational tools are employed in the initial design process, the use of physical models provides necessary information which can only be obtained through the act of making. Rather than using this 1:1 model as a way of communicating ideas of fully realised designs, the prototype instead acts as a method for testing material properties, fabrication strategies and construction techniques, all of which lead to the production of both novel structures and new knowledge. Contrary to traditional academic projects, where value can be assessed by examining the end product, or final design, the Design/Build projects presented here assign value to the design process itself, where the development of learning is only possible through a constant feedback loop of production and analysis.

While the fabrication of models is ubiquitous in all schools of architecture, the position that these models take is vastly different. The traditional model has often been used to represent or communicate an idea, operating in many ways as a metaphor for a design principle or intent. At the same time, in contemporary architecture education, the fabrication of models as prototypes has become commonplace, with the widespread implementation of facilities such as digital fabrication laboratories internationally. This shift has redefined the very understanding of building, as “not just the implementation of represented conceptions, but rather seen as a process by which one discovers and explores” (Hensel and Hermansen Cordua, 2015a). However, it seems as if prototyping, particularly at the large-scale, is often categorised under the heading of Design/Build. This classification is however misleading, in that not all Design/Build projects are alike. While most projects of this kind are designed and built by the same team, some are highly exploratory, while others aim to deliver an architectural project (building, structure or interior) in its more traditional definition. This distinction appears to be borne not from the physical artefact produced, however, but in the process of production itself. Hensel and Hermansen Cordua (2015b) further state “studies in most schools of architecture are omitting crucial aspects of the architectural process, and in so doing reinforce the chasm between education, research and practice.”

**RESEARCH AS EDUCATION**

Within those few schools of architecture where the integration of education, research and practice are paramount, the relationships between them play a crucial role in the definition of the endeavour itself. The Design/Build project in the Emergent Technologies and Design Master Programme at the Architectural Association School of Architecture (EmTech), defines this approach as founded in the atelier tradition of many architects such as Jean Prouvé and Charles and Ray Eames, where the production of the prototype is a design tool rather than a design itself. In the late 1930s, for example, Jean Prouvé began to test the design of light and deployable structures such as a tent and a hut. These initial constructions were developed within the production of the one-to-one, rather than describe a state of completion of the construction itself (Centre George Pompidou, 2009). It could be argued, then, that these experiments in deployable structures were in fact prototypes of Prouvé’s Tropical House, testing and idea of production (in this case, deployability) rather than the development of a specific method of production.

Within this structure of process and production, EmTech aims to gain knowledge around innovative strategies of material systems and fabrication logics through large-scale prototyping. While these explorations pursue the development of research as a contribution to the larger body of work within material production, it too focuses on the education of students through the research and design process itself, via prototyping. Prototyping thus becomes a mechanism by which students understand properties of materials and
fabrication processes, but also in collaborative work and the organisation of design workflows.

While EmTech has designed and built numerous large-scale projects since its inception in 2001, the development of its most recent Design/Build works, specifically from 2012-2015, have focused primarily on the investigation of a design intent, or the exploration of an idea, in the Prouvéan manner, rather than the construction of a specific typological artefact. In each of the three projects, beginning from a one-week design competition, organised as extracurricular and unassessed activities and ultimately undertaken by a subset of students from the EmTech studio over the course of approximately 9 months, a brief to design a pavilion was used as a generic vehicle to explore the stipulated design idea. This prescription allowed for the simplification of the problem at hand, providing the students with an opportunity to focus on learning through prototyping rather than allocating resources toward practical requirements of programme or environment (with the exception of structural performance). Interestingly, despite this omission, these architectural effects emerged unexpectedly through the process of prototyping design.

CASE STUDY 01: CARBON CURVE, 2013

The 2012-2013 cohort in the EmTech Programme were asked to design and build a continuous surface capable of producing differentiated effects through controlling the variable stiffness of a plywood composite material. The design competition produced two similar and complimentary design ideas; an integrated design method of appropriating cutting patterns onto plywood sheets derived from surface curvature analyses. The primary material technique had been previously developed during the programme’s first studio module by a group of students exploring the design of a perforation pattern applied to sheets of plywood. This technique allowed the plywood to perform unperforated, as
a stiff board, or highly perforated, with a 50% reduction in overall material, and somewhat like a fabric. A secondary material technique was included where pre-impregnated carbon fibre tape was bonded to the curved plywood sheets in order to retain curvature and connect individual panels together, forming a continuous surface [Greenberg and Körner, 2013].

Developing this material approach within the context of a Design/Build project required extensive physical prototyping. While the effects of material manipulation had been previously understood, the students had no prior experience working with the carbon fibre tape. While materially, its properties were understood, the construction of a rigidified panel had not been tested previously and the assembly of these panels were not previously defined. Therefore, a series of full-scale tests were required so that the students would be able to gain knowledge in the relationship between geometry, material properties, fabrication and construction.

After the development of numerous experiments joining two panels together, the students set out to build 50% of the total designed pavilion in Hooke Park, the Architectural Association’s woodland campus. This opportunity allowed the students to test and develop the construction process at full-scale. After 6 days of fabrication and construction, 4 sections of the pavilion were successfully erected on-site. However, overnight, the pavilion collapsed due to large changes in humidity in the outdoor environment, as well as a lack of structural performance of the carbon fibre tape due to poor lamination and insufficient thickness. While the pavilion itself ultimately failed, the prototype was largely successful, in that the knowledge gained from this test would not be possible within any other context. While Finite Element Analysis was used to analyse the global geometry without any perforations, it could have also been used to predict some of the perforated surface behaviour prior to construction; however, the complexity of the surface patterning and resulting material performance required physical prototyping to understand its structural behaviour. Furthermore, the students gained a clear understanding of the construction process, learning through making, and also in the way that the structure failed through live interactions. Furthermore, prior to failure, the differential patterns generated produced emergent effects with regard to views to the forest as well as light and shadow patterns generated, which had not been designed for previously. The prototype therefore afforded the opportunity for students to learn the relationship between structural performance and spatial effects through the simple material technique of pattern application.
CASE STUDY 02: FINGERS CROSSED, 2014

Fingers Crossed was the Design/Build project developed by students in the 2013-2014 cohort within the Emergent Technologies and Design Programme. While this project was initiated as a collaboration with the Timber Research and Development Association (TRADA) and Arup as a quickly constructable pavilion designed for the London Design Festival 2014 and Timber Expo 2014, the Emergent Technologies and Design Programme approached it not as the finite delivery of a commissioned project, but as the exploration of an idea around demountability. In this regard, a material system was developed where all connections were made through friction joints, rather than through metal connections. Similar to Carbon Curve, the principal material technique came from a previous studio module, where students rigorously tested the friction capacity between two comb-shaped geometries. This material technique was developed further as the joinery solution in the design of two bending-active catenary forms made of plywood, held in place by waffle-jointed plywood footings (Greenberg, 2015).

Numerous initial material tests, studying material thickness, tooth width and length and gap width were conducted as tabletop experiments in order to gain an understanding of initial material behaviour. However, these tests rapidly required full-scale production. Through physical prototyping therefore, students were able to gain an understanding of the behaviour of friction forces. More importantly, though, students developed an understanding for the role of tolerances within the design process. Therefore, prototyping became the main mechanism for the procurement of fabrication expertise. By linking the performance of plywood through friction forces with the cutting capabilities provided by a 3-axis CNC mill, the students were able to gain knowledge on element and gap sizing to make construction possible. This process provided a contribution both to the wider research field but also to the personal proficiency of fabrication and construction methods.

CASE STUDY 03: THE TWIST, 2015

In 2014-2015, EmTech again partnered with TRADA in the delivery of a pavilion for Timber Expo 2015. As in previous design/build projects, The TWIST was developed as a response to a specific call for ideas rather than in the delivery of a finalised pavilion design. The TWIST was undertaken to explore the idea of exploiting bending and twisting behaviour noticeable in plywood sheets. The proposal originated as the design of a Möbius geometry, where straight plywood members, referred to as wings, met stiff curved members, called ribs, at variable locations along their lengths, causing them to twist. This twisting generated a second direction of curvature along the surface, resulting in a doubly-curved surface geometry.

This material performance was tested in principle through precise geometric models as well as through tabletop material experiments. When this technique was first tested as a one-to-one prototype at the AA’s Hooke Park, however, major structural issues became apparent, thus validating the importance of the prototyping process. A stiff edge beam was introduced in order to provide structural rigidity. Through the development of this prototype, the structural system of The TWiST changed from one where the twisting wings would provide structural stiffness to a system of stiff frames created between ribs and edge beam. The wings, then, generated a surface that filled in these frames and tied these two elements together fully. Prototyping, in the case of The TWIST, was used as a mechanism not only to explore structural behaviour, but subsequently as a tool to develop detail design. All joints were designed through full-scale constructions, and the knowledge of the material system as a whole developed through a large body of research through prototyping.
Because the Möbius was intended to be used as an inhabitable pavilion, the geometry was designed to incorporate a cantilever, providing an entrance to the interior space. This cantilever, understood to be the most geometrically and structurally complex part of the pavilion was thus prototyped again for the AA’s Projects Review 2015 in order to gain a better understanding of its performance. Through this process, a new edge connection design was developed, providing further stiffness to the cantilever. The TWIST was prototyped once more, and for the first time as a complete structure for Timber Expo 2015. Although the entire assembly process had not been explored previously, this prototype provided the opportunity to test this method on site. While issues of tolerance required real-time adjustments to the preconceived design, such as metal splicing in certain areas in order to maintain structural continuity, The TWIST was successfully prototyped in full.

DIGITAL AND MATERIAL COMPUTATION

In a number of contemporary architecture education models, digital computation is being used as a method to simulate, predict and design physical behaviour, sometimes in lieu of physical modelling. In all three examples explored above, however, the use of computation within the design process is employed in parallel to physical modelling. Digital computation was used in the generation of geometry, the integration of material properties within digital models, as well as in the simulation of physical behaviour through Finite Element Modelling. While these tools provide the potential for solutions to a number of issues faced, students can often struggle to find agency in the production of these digital models, where, as Barkow and Leibinger suggest (2012) “the experience of material effect and haptic workability cannot be adequately simulated.” This is particularly true in the understanding of scaling principles, connectivity issues, and in production of unexpected architectural effects. While simulation through digital computation is valuable, it fosters a disconnect between the tool used to experiment and the production of the experiment itself. Engaging in making through physical prototyping therefore requires that the student test strategies at full scale, where “implications of detailing and construction emerged through the making of the prototypes with material mockups and test pieces acting as visual specifications,” (Iwamoto and Scott, 2001).

This process facilitates the integration of the tool acting on a material, the material itself, as well as the technique used to physically make the prototype. Interestingly, the process of physical production also allows for unexpected events to occur. Often in computational simulation, unforeseen circumstances will be flagged as errors, and will not allow a procedure to run. While the accuracy provided by digital processes is preferred to the imprecisions which arise from human error in the physical world, discoveries can be made
from the observation and evaluation of unplanned events, from structural innovations to spatial or visual findings.

The TWIST was first prototyped in Hooke Park, where the lack of stiffness in the edge beam resulted in structural failure (above left). Learning from this construction, the edge beam was stiffened for a subsequent prototype installed at Timber Expo 2015 (above right).

CONCLUSIONS

Prototyping in architectural education is not new, nor a necessarily novel approach to design. However, it is the attitude toward prototyping within the academic setting which is particularly innovative. Most Design/Build projects within academia aim to deliver a final product — a fully realised pavilion, interior, or in some cases, residential projects. The goals of the prototype within the three projects described here, however, focus on the knowledge gained through the development of the performative model itself. In this regard, there is no final design as such, only a logistical decision to end the research undertaken by the students. While this often leaves work unfinished, it opens new avenues of research for further exploration. Rather than deliver a conclusive, absolute product, the prototype enables students to gain knowledge in material, fabrication and structural technologies which facilitate larger research projects in greater depth. Thus, the prototype is not a means to an end but a mechanism for learning, providing students the opportunity to ask more appropriate questions in future endeavours.

Modelling through physical prototyping within this context thus develops specialisations amongst students, with some focusing on detailing and machining while others focus on procurement or structural analysis. This specificity allows for individuals or small groups to gain expertise in a focused area of research, but also requires each to communicate effectively within a collaborative environment. In Designing Education, John Nastasi (2012), Director of the Product-Architecture Lab at the Stevens Institute of Technology, writes about the changing nature of architecture as a discipline. He suggests that the design and construction industry will be highly collaborative, although most current models of architectural education are individual. This holds true for a great number of innovative contemporary practices, where collaboration exists not only between architects...
working on the same project, but between those architects and their clients as well as with various consultants. With this in mind, EmTech Design/Build projects stress the importance of learning and executing within a team. While greater success is unequivocally achieved in the context of a collaborative environment, the structure itself provides students the opportunity to learn how to work within a group, by proffering a domain where multiple approaches must be tested and implemented, and where various cultures and values must be discussed and considered. The value of these interactions, while not formally assessed, contribute to the development of a rich body of knowledge that far surpasses the research benefit of the project itself.

Digital computational models were used to generate fabrication files, and as a guide for the physical prototyping at Timber Expo 2015. While the digital model was geometrically accurate, experience gained through numerous iterations of physical modelling allowed for control of inaccuracies due to material properties and tolerances.

REFERENCES


Crafting skins: Spatial and structural properties of laminated surfaces

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INTRODUCTION AND BACKGROUND

The explorations started with a curiosity in layering sheet material: a strictly additive assembly process that could potentially serve as a conceptual translation of 3-D printing into full-scale construction. Particularly wood panels are conventionally composed of several layers of thinner material, only to be cut again in the assembly process in order to be joined with other panels. The investigations in laminated surfaces are driven by the motivation to explore new functional and creative potentials, and to take advantage of the emerging lightweight and spatial components for the application as building skins. The structural performance can eliminate usual limitation in dimensions between load bearing members, and the spatial properties can provide for an integration of diverse functions into the skin.

Lamination is used to manufacture elements in multiple layers so that the composite resultant material achieves the desired balance of strength, stability, sound or thermal insulation, and appearance from a tailored combination of different materials. One of the most widely used laminates is plywood - a sheet material produced by gluing and pressing thin layers of wood veneer. The two aspects of the technique that govern the strength and stiffness of the end product are the number of veneer layers in the ply and the orientation of grains within each layer. The grains are orientated perpendicular or at an angle with respect to each other and layers are glued in odd numbers providing enhanced strength. Since the invention of plywood in the late eighteenth century, when the main applications were in shipping industry, the technology has expanded exponentially both in the fabrication techniques (with the recent progress in CAD/CAM tools) and in the diverse fields of applications. Other sheet materials such as metal sheets and composite materials have further varied and significant uses range still from shipping to aeronautical, automobile, and construction industries. A growing current interest in the process of lamination to develop unconventional materials is evident in the recent research, aiming for composite materials and recycled elements, such as heat pressure lamination technique to fabricate flat panels from recycled polyethylene-foil or shopping bags.

PREMISE

Undoubtedly, a vast scope and subsequent resourceful research exists on the application of flat panels in the computation of curved geometries. The same applies to lamination processes of new materials, mostly by applying heat and pressure, or welding techniques and chemical adhesives. However, there
are relatively limited precedents that explore the lamination process through geometric variation and morphological differentiation within its layers. For instance, plywood sheets have uniform and linear layers, with no variation in their thickness, or differentiation between the grades of core and surface veneer layers. There is no experimentation to develop non-uniform and non-linearly behaving hierarchical formation of layers with potentially more effective and efficient design solutions. This research positions itself in the premise of this unexplored design solution space and aims to formulate a system of design morphologies based on changing hierarchy of layers within the assemblies.

The research in its first stage studies the implications of incorporating hierarchy within layers – both structurally and formally. The second stage of investigation involves studying assemblies with non-planar and non-linear layers (for example, bending some or all veneers). The third stage studies assemblies having non-uniform layers with variation in orientation and/or thickness of layers. At the stage we coined the term dynamic hierarchies to describe a concept, where the role of the core and surface layers within lamination is interchangeable within the assembly. The fourth stage of the research experiments with applying this concept on multi-material combinations. The results are evaluated for the corresponding structural and formal advantages, shortcomings and variation in assembly properties.

STATE OF THE ART

While the concept of bending/curving layers in laminates is explored intelligently (both for strengthened structure and innovative design) in recent timber products like Corruven or CoreLam, both taking advantage of a corrugated core layer and developed by Canadian companies. The latter was translated into furniture design objects by Benjamin Hubert. Some of the few other examples of design explorations that follow related concepts include the Enignum II Table by Joseph Walsh and the Flow chair by Cheng-Tsung Feng and Kao-Min Chen. Besides furniture design it is noteworthy to include preliminary approaches in fashion design. An outstanding example is the A-POC (A Piece of Cloth) project by Issey Miyake, which explores 3-dimensional attire formations by stitching and cutting through a continuous multilayered fabric. The project is particularly stimulating for its investigations in art and craftsmanship in addition to adopting the minimal waste approach (no figures due to copyright restrictions: please follow the provided links in the text for illustrations).

This research on laminated surfaces goes beyond the uniformity of these products and adds another layer of complexity through the introduction of dynamic hierarchies in the layers. The unique advantage of creating 3-dimensional morphologies from 2-dimensional sheets, through least wastage makes the differentiated lamination of sheet materials significantly more optimised and an economical choice of construction material. Apart from sheet materials having the advantages of ease of transport and fabrication (through laser cutting/water jet cutting using flat-bed) in comparison to other construction materials (such as solid timber, steel tubes, cables etc), these sheets also display bending and curving behaviour that can be used specifically to shape and strengthen the construction.

HYPOTHESIS

The goal of the research is to develop laminated sheet assemblies with enhanced structural performance (in addition to variation in characteristics like sound and heat insulation), by controlling the strength and stability of the composite result through modulation in bending curvature and joinery of layers. This proposal exceeds the existing conventional bending/curving and pressing techniques of construction and fabrication of laminates by incorporating design needs into the material system for producing efficient morphologies.
It explores new concepts of lamination such as dynamic hierarchical layering through initial formal experimentation as part of a design studio and then focused computational explorations and evaluation through physical experiments. The progressive design iterations focus on operative reciprocity between design and fabrication, in an investigative process of crafting skins.

METHODOLOGY

The investigations have been conducted in two parallel strands. The explorations of concurrent design research studios have been integrated in the research and offered a variety of speculative approaches that will be summarised here. The following chapters will focus on the empirical research into the lamination of sheet materials to design self-supportive structural surfaces with potentially varied architectural applications. The methodological aspects of design processes with the integration of physical experimentation and parametric tools, bridging the prevailing segregation of design, planning and building will be briefly outlined.

The primary motivation for this research is derived from (but is not limited to) timber production processes, and the manufacturing of plywood from layers of veneer. The research also investigates metal sheet materials like aluminium in the context of layering and lamination processes. A future expansion of the research will include composite materials, where the use of renewable and recyclable materials will be of particular interest. At the current stage the experiments highlight two specific aspects of lamination – structural performance and spatial characteristics; both are studied in the context of potential architectural applications.
PRELIMINARY EXPERIMENTS

Design Studio
The studio was titled Building Skins, provoking a critical view on the classical notion of segregating building functions into discreet systems, but instead reading it as an act of building (crafting) skins. It engaged the students to explore the concept of crafting surface morphologies by making shell-like components using materials like paper, wood veneer, plastic and metal sheets. Parametric design tools and generative algorithms were used to derive component based assemblies, which were then constructed using a mix of digital and manual fabrication processes like laser and water-jet cutting, vacuum forming and so on. The main objective of these studio explorations was to understand the material characteristics and to utilise them to design three-dimensional assemblies from two-dimensional sheets, through techniques of lamination and delamination. The series of variable and differentiated results produced were then analysed for their architectural characteristics (like spatial enclosures), strength vs stability variation and scalability limitations. The initially abstract and geometric explorations in the studio established the base and premise for translations into a repertoire of architectural articulation and formal experiments in the design studio, and for further material lamination in the academic research (Figure 1).

The 13 different design outcomes resulting from the studio project were compared and evaluated in three categories based on the number of layers, the method of transformation
before or during lamination (or de-lamination) and finally the fabrication technique used for crafting the composite laminated sheet assembly (Figure 2).

**Uni-layered, Bi-layered, Multi-layered Assemblies**

While most of the projects started with uni-layered transformations to study the material behaviour using small-scale explorations, the design process eventually led to adding more layers (literally) of complexities to the assemblies. The number of layers plays a vital role not only in defining the strength of the assemblies, but also in determining the behavioural characteristics like bending/folding etc. It was hence crucial to study the strategic correlation between the number of layers in the designs and formal explorations evolved in the projects.

**Plain, Curved and Folded Formations**

The transformation processes explored to deform the sheets could be categorised broadly into being planar, bent/curved and folded. By using combinations of these transformative processes, more intricately crafted techniques of pinching, twisting and interlocking were explored intelligently to develop fairly complex assembly systems. Although most of the choice of deformations (either bending or folding) essentially emerged from the material properties, joinery and material orientation also played a significant role in determining the global geometry (with anisotropic materials allowing folding and bending in only certain orientation).

**Scoring, Cutting and Joining**

In addition to deformation explored within the materials, the use of advanced fabrication technologies assisted in developing further enhanced complex systems. For example, scoring and cutting using laser-cutting or water-jet cutting displays how digital fabrication technology can evolve into developing a craft-life assembly system with structurally and spatially improved designs (Figure 3). Conversely, additive techniques as simple as gluing after folding algorithmically (by following specific set rules) can result in complex origami-like surfaces and patterns with potential of intricate architectural applications.

**HIERARCHY OF LAYERS**

The initial studio experiments facilitated in providing the proof of the strong relationship between the global form of the assemblies and the manner of connection between the sub-structural layers by establishing a hierarchy amongst the lamination layers. This essentially means that shape, strength and stability of one layer was governed by the manner, order
and spacing of its connection to the subsequent layers. It was hence essential to study these formal implications emerging from controlling and varying the parameters in these mixed-hierarchical laminated sheet structures.

The concept of scalability becomes crucial for a comprehensive understanding of the potential and limitations of designs that emerged from the studio. For example, while most projects showed significant potential of emergent designs at the smaller scale of component design and assembly systems, the same concepts faced limitations of feasibility and constructability when applied too literally on a relatively larger scale of architectural applications. Nevertheless the formal and material experiments lead to the development of specific formal repertoires and to “real” [physical] constraints in the constant translation between computational and physical models. Some of the studies resulted in multilayered architectural models with complex spatial relations (Figure 4).

MATERIAL EXPERIMENTS

Academic Research

Through a series of physical test cases and design prototypes, the research derives fabrication processes that coalesce the two performative goals of improved structural capability and user-based functionality. Morphologically, the hierarchy of the lamination layers plays a crucial role in determining the global form of the assemblies in addition to governing the structural and spatial behaviour. Hence, the experiments conducted are focused on using this property of hierarchy of layers to modulate the performative properties of assemblies. In a first stage the studies focus on the rules, behaviour and effect of existing uniform hierarchy. This phenomenon of uniformity is then tweaked to develop a concept, for which the term dynamic hierarchy is coined, wherein the strict order and differentiation of layers is intercepted to generate a complex intra-connected and interchangeable hierarchical layering system.

This novel approach to the conventional sheet lamination process opens a plethora of unexplored morphology design solution space having a wide range of effective applications. The two significant fabrication aspects of investigation of construction of these dynamically hierarchical laminated sheet assemblies are production and assembly
processes. While studying the assembly system, the research explores potential design applications of incremental scales as test cases and proof-of-concept of the on-going investigation.

Variables/Parameters
For the sake of nomenclature simplicity and ease of understanding of the system behaviour, we consider sheet layers with a fixed length and width. In the context of this paper, a module is defined as a single bent or folded geometry and an assembly is the term used to describe multiple modules connected using lamination processes. Hierarchy is the term used to describe the sequence of arrangement of layers (main layers defining the global form versus subordinate layers sandwiched between the main layers). The variables or parameters experimented with were firstly, horizontal distance between the connections of modules; secondly, the vertical distance between the connections of modules and thirdly, the number of sheet materials forming the modules. The variation in these parameters subsequently resulted in respective variation in the number of modules within a fixed length of assembly (Figure 5).

Uniform Hierarchy + Uniform Deformation
The natural hierarchy established in the assemblies is based on essentially the function and position of the subordinate layers. The outer layers which governed the global form were the main layers while the core layers sandwiched between the two outer boundary main layers determined the thickness, strength and flexibility of the assembly. The first stage of study involved “uniformly” varying only the height and/or width of the core layer modules. Thus a series of morphologies produced exhibited uniform hierarchy and uniform deformation (Figure 6).
Uniform Hierarchy + Non-uniform Deformation
The next layer of variation in the study was introduced by keeping the hierarchy still uniform, but transforming the core layer modules non-uniformly. The core layers were deformed in varying heights and/or widths (keeping the number of layers constant) and the corresponding effect on the outer main layers was studied. The global form immediately re-morphed based on the amount of variation in the core layers. The global form and the main layer morphology, thus is the function of core layer parameters. The width, height, number and change in these parameters of the core layer modules significantly determined the strength, curvature and flexibility of the entire assembly. This property was the principle driving factor of the further research as it can be now used to manipulate and control the overall characteristics of the assembly (Figure 7).

Dynamic Hierarchy + Uniform Deformation
The next stage of investigation involved exploring the possibility of non-uniform hierarchy. This concept essentially involves moving away from the strict differentiation and categorisation of the assembly layers. The aim was to study the results emerging from the possibility of switching the role of layers from being core layers to main layers throughout the assembly. As observed earlier, the core layers determined the characteristics of the main layers and the assembly. So if the roles are switched, the main layers would become the core layers within the assembly while the originally core layers would emerge as the main layers defining the global form. This dynamic hierarchy introduced displays the potential of the assemblies performing as integrated systems emergent from material properties, component morphology and connection methods. This added complexity makes the laminated sheet assemblies system non-linear expanding the domain of design solution space exponentially (Figure 8).

Spatial Cavities from Combinations in Assemblies
The next stage of experimentation involved exploring the potential of architectural applications by introducing spatially usable characteristics. In order to use the variation in core layers (that resulted in variation in global form) as the tool to carve out spaces, a number of assemblies were now connected with each other (after mirroring in position). The results displayed varying cavities emerging based on alignment and positioning. Upon analysis, this concept displayed multiple advantages that enhanced the performance of the system. Spatially, the cavities had the potential of being usable for multiple purposes like storage, visual connection etc. based on the scale. However, structurally, these cavities helped in material reduction while maintaining the strength of the system. Based on the geometries, some of the cavities enhanced even the stability of the assemblies. For example, the assemblies with diametrically symmetrical cavities had enhanced stability and load bearing capacity compared to the assemblies with asymmetrical cavities. This is because the symmetrical cavities maintain the centre of gravity within the system. The resultant morphologies thus exhibited self-stability with potential of various architectural applications. Furthermore, numerous formal explorations were possible from limited layers and/or parameters. These characteristics of improved spatial and structural performance in addition to material optimization were primary motivations of further research into the subjects (Figure 9).

Physical Experiments
The aim of the next set of experiments was to test the hypothesis and reaffirm the inferences derived from the explorations thus far. The experiments were categorised into physical and digital based on the medium used. However, the process followed was reciprocal wherein the physical experiments assisted the digital set-up and vice versa. The approach aimed
at being more integrative rather than discriminative in order have coherent and efficient results.

The physical experiments aimed at studying the effect of tangible material properties on the assembly structure and morphology. Although these material properties can easily be simulated digitally to predict the behaviour of the system, factors such as material quality, gradation, sequence of making etc. which have a significant impact on the result are rarely taken into account in the digital environment. Moreover, the physical experiments revealed a number of real-world limitations faced during the fabrication of these assemblies, especially while working with different materials.

**Paper**

Paper, being homogenous material was chosen to work with mainly because it is rarely considered and strong and stable building material by itself. The challenge was to test if the concept of lamination induced considerable amount of strength and stability in the assemblies. Various prevalent parallel fields of modular paper-architecture were also briefly investigated; for example “Origamics” by Marco Hemmerling (Digital Folding in
Architecture) and interactive kinetic folded structures by Filipa Osorio (Interaction with Kinetic Folded Surface). The experiments we followed, however, were aimed to study the fundamental principles and structural benefits of folding/curving laminated layers through varying geometrical parameters. The improved structural performance in the resultant modules as listed below showed promising potential in emergent behaviour exhibited by laminated sheet assemblies.

**Veneer**

Veneer sheet material was the only anisotropic material experimented with in the research. Interestingly, the results emerging from working with the veneer models showed maximum impact of subtle changes and variation (and even errors) in the core layers on the global form and overall behaviour or the laminated sheet assemblies. As anticipated, the orientation of the veneer sheets and its grains played a significant role in determining the strength, stability, flexibility and durability of the resultant morphologies. The goal was to study the relationship between the parameters and resulting characteristics in order to design improvised connection systems. For example, as the width of the sheets increased, the connections failed in overcoming the brittleness of the veneer in lateral direction. The solution to this limitation was provided by cutting the width of the veneer along the grain orientation and then bending the resultant lesser width veneer components more flexibly along its natural curvature. This strategic solution facilitated in not just improving the flexibility of the assembly in lateral direction, but also turned out to be beneficial from design point of view (Figure 10).

**Metal**

Metal, which is widely used as cladding material, in antithesis to previous notions of steel being the “bones” of architecture wherein it expressed strength and sturdiness, now reveals a softer, highly sculptural, and almost textile quality when used as skins. Metal is also widely getting explored at its compositional level through texturising, a process that improves rigidity through increase in cross sectional depths of thin gauges in addition to adding aesthetic appearance. Interestingly, innovative methods of fabrication in steel construction have been explored both formally and fabrication-wise. An apt example of such research is in the field of incremental sheet metal forming using robotic tools (Kalo and Neswum, 2014). In addition to conventional bending, folding and curving, concepts like creasing and double twisting are also being investigated as ways of maximizing structural performance. Even studies on forming partially doubly curved surfaces out of flat sheet material through 3-D puzzle approach bring to light the plethora of architectural applications emerging from use of digital fabrication processes on sheet materials (Kilian, 2010). This research, while taking inspiration from the parallel studies in metal sheet construction, brings back the focus on the concept of hierarchical layered assemblies (Figure 11).

The aluminium sheet assemblies displayed more strength and load bearing capacity compared to the corresponding paper and veneer modules. The homogenous nature of the material also served in reducing the limitations faced due to orientation and/or grain direction. However, due to the inherent malleable nature of the metal sheets, there was considerable amount of undesirable deformation at the connections and during manual fabrication of the assemblies. These errors, however, could be well avoided by adapting a complete digital fabrication process using water-jet milling, drilling and robotically assisted assembly set up.
Digital
The digital platforms and tools like Rhino3D and Grasshopper were used to explore the design space emerging from the concept of dynamic hierarchy. As a conscious decision, the design process not entirely computed digitally or automated through programming. The main reason for this strategic move was to restrict the research moving into the direction of becoming primarily a form-finding exercise, thus maintain the focus on lamination process and architectural applications. The digital explorations thus followed a fairly intuitive design development with an underlying goal of exploring architectural usability. The fixation points determine the deformation of single sheets within the elastic range of the material (Figure 12).

The explorations below are limited to 4 layers of sheets within the lamination assembly. The top and bottom layers always maintain the function of being the main layers thus defining the base of the global form of the assembly. The remaining two layers, however, switch between being a main structural layer to being supporting core layer and vice versa. Inarguably, a slight variation in this dynamic hierarchy now results in a large variation in the resultant of the global form, strength and stability (Figure 13).

CONCLUSION AND OUTLOOK
Review and critique on the studio outcomes displayed promising emergent-design potentials, especially from the view of structural and spatial assemblies. The intelligent crafting of material components to strengthen and spatialise the 2-dimensional flat sheets with the help of digital design and fabrication resulted in designs that opened an array of research premises to study laminated sheet assemblies. For example, evaluating laminated...
assemblies on the basis of variation in layering, transformation (bending/ folding etc.) and in fabrication techniques helped in understanding the merits and limitations of various transformations v/s available fabrication tools.

The observed categories in the studio became then central in determining constraints and defining the main parameters of the explorations carried out in further research. It also inspired to maintain the focus of research on simple techniques and an incremental introduction of complexity through experimenting with basic parameters such as the number of layers, and connection rules. Thus process of joinery and system of connections became a crucial constraint to the research, both for its morphological and its structural implications. Further experiments will be conducted by the integration of structural

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure12.png}
\caption{Waterjet cut and digitally predetermined configurations.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure13.png}
\caption{Dynamic changes in layer hierarchies, waterjet cut and assembled without material deformation (material stays within the elastic range of deformation).}
\end{figure}
simulation and mathematical evaluation into the computational models. The physical experiments will be expanded by the examination of multi-material assemblies and composite materials.

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REFERENCES


From continuous to discrete fabrication

Gilles Retsin, Manuel Jimenez Garcia, Vicente Soler
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MIND THE GAP

With an exponential increase in the possibilities of computation and computer-controlled fabrication, the idea of an architecture of extreme detail and resolution becomes feasible. This possibility has been extensively explored by designers such as Benjamin Dillenburger and Michael Hansmeyer. It became one of the conceptual drivers in the work of practices such as Biothing and TheVeryMany. SoftKill's Protohouse project (2012) is also an early exploration of an architecture with extreme detail. The advantages of increasing the resolution of architecture are manifold. According to Dillenburger and Hansmeyer, “3D printing introduces a paradigm shift in architecture, where the amount of information and complexity of the output is no longer a relevant constraint” (Dillenburger and Hansmeyer. 2013). Architecture can start to respond in a very precise way to structural criteria or external forces and demands. An increased level of detail also offers new opportunities for aesthetic exploration.

The increase in computational power, availability of industrial robots in academia and distribution of programming knowledge has accelerated computational design research in the past few years. Mass Open Online Classes (MOOC) and other initiatives such as the Plethora Project have made it relatively easy for generations of students and researchers to pick up even more complex code. Research in advanced fabrication has increasingly become more accessible.

However, although it is now feasible to build up complex simulations with millions of particles, the resultant simulations are often disconnected from the actual fabrication process. There is a gap between the digital design process and the fabrication method. This paper will further argue that this gap exists as a result of a misalignment between the machine and the design process. Often, simulation doesn’t take fabrication into account and designers or researchers prefer to post-rationalise the resultant forms. The possibility of a more holistic approach, where a designer is in control of both the computational design process and the fabrication is an evolution which has only become feasible in recent years with the proliferation of new robotic technologies and digital knowledge.

Mario Carpo divides the past 20 years of digitally intelligent architecture into a first and second digital age. The first digital age, with people like Greg Lynn, Bernard Cache and Zaha Hadid; is interested in the idea of continuity. Architecture is understood as a continuously evolving body - a kind of embryo developing under the pressure of an external field of forces. To become
reality, the organic, continuous forms of the first digital age had to be subdivided into CNC-milled panels and frames. The first digital age remained a “paper architecture” as it had no intrinsic link with concepts of fabrication. In contrast, the second digital age understands computational processes as fundamentally discrete. EZCT explored this idea of discreteness through their design of a voxel-based chair. However, just as in the first digital age, this second digital age of “big data” is in intrinsic trouble with tectonics and materialization. To materialize the second digital age’s discrete explorations, continuous fabrication techniques are required: cnc-milling molds or 3D printing. This causes a misalignment between the computational method, which is able to negotiate millions of particles, and the hermetic constraints of these continuous fabrication processes. To translate the complex structures generated in the simulation, data often has to be reduced to a series of slices, contours or layered toolpaths. The translation to physical form reduces the complexity of the structures, effectively removing information. Since the actual organisation of material has not been computed in the simulation, it remains a post-rationalised process. The work presented in this paper attempts to negotiate this gap, by introducing machine constraints as generative drivers of the computational process. The research attempts to establish a one to one relationship between the organisation of digital and physical data.

This paper will describe in detail how this gap can be negotiated within a fabrication framework based on continuous 3D printing. The first iteration of projects described uses continuous computational systems to integrate fabrication constraints within the design method. The second iteration of this research attempts to utilise discrete computational models. As a brief introduction, a third iteration will be introduced, which proposes discrete methods for both computation and fabrication.

TOWARDS LARGE SCALE ADDITIVE MANUFACTURING

The projects described in this paper are produced in a research-through-teaching context at Research Cluster 4 (RC4) in the Bartlett School of Architecture, UCL. RC4 is a part of B.PRO, an umbrella of post-graduate programs in architecture at the Bartlett. The cluster is led by Gilles Retsin and Manuel Jiménez García, and started out in 2013. Since the start of the cluster, there has been a close collaboration with Vicente Soler. From the early stages, the research agenda of RC4 has focused on large scale additive manufacturing.
for architecture. The research makes use of industrial robots, which are turned into 3D printers by attaching custom designed end-effectors for additive manufacturing. This effectively turns industrial robots into large format 3D printers. RC4 is part of a larger body of research in large scale printing. Large scale 3D printing for architecture is often associated with Behrokh Khoshnevis’ Contour Crafting procedure. Contour Crafting enables the printing of large scale concrete structures from a gantry structure. A similar process developed by WinSun in Shanghai has entered the commercial market, producing a large number of full scale prototypes in the past few years. Enrico Dini’s D-Shape printer is also based on a large gentry, but it uses a binder to solidify stone dust into a sandstone-like material. While these precedents successfully innovative with the development of a machine, they are not innovative with the design methodology itself. They are effectively investigating only one side of the gap - the fabrication process. On the other hand, the research by Dillenburger and Hansmeyer is specifically focused only on design, and not on fabrication. They assume the existence of a large scale 3D printer, using a commercially available printer such as the Voxeljet sand printers.

There are a number of important precedents using robots as 3D printers. By using a robot, researchers can skip the expensive and slow process of developing a new, large scale machine from scratch. IAAC research led by Marta-Male Alemany was the first to focus on robotic processes for additive manufacturing in an architectural context. Gramazio and Kohler’s research at the Future Cities Laboratory in Singapore was the first to introduce spatial plastic extrusion with a robot arm. Outside of architecture, the aerospace industry has been investigating metal sintering processes with robots.
Research in RC4 starts out with the choice of a specific material and printing process. Students start the research by exploring material properties. For instance, in the case of concrete or plastic, the material is tested for consistency of extrusion, through a series of manual tests. As a second step, students develop a custom-built extruder. This extruder is then first manually tested, and later on mounted on a robot. Multiple iterations of the tool head are developed. Over the past two years RC4 developed more than seven iterations of a plastic filament extruder, gradually increasing speed and precision. The designs of this extruder are available for a next generation of students to further develop. The tool is always intrinsically linked with a chosen material for printing. RC4 has developed tools for robotic 3D printing in clay, plastic, sand, concrete and timber.

Students synthesize the computational process for tool path generation in a small applet, programmed in Processing. The applet has a graphic interface for users to interact with the complex set of constraints related to the fabrication process. The applet fuses all the code necessary to generate the tool-path into one single process, which is visualised as a design environment. It allows designers to quickly generate possible versions of their work, in a more playful way, without being overly constrained by fabrication. RC4 research advocates the idea that architecture should develop its own algorithmic methodologies, based on constraints from the fabrication process, rather than borrowing methods from natural systems. Most of the algorithms underlying the work of the second digital age (Carpo, 2012), such as recursive subdivision, fractal growth, cell-division, agents or reaction-diffusion are driven by observations into natural systems. The algorithms can be considered “found objects”, which don’t take into account constraints relating to materialization, structure or constructability.

This paper will discuss a gradual shift from continuous to discrete computation using four projects, spread over two years of research. Filamentrics and CurVoxels, which are based on lightweight plastics; and Microstrata and Amalgama, which are based on compression
materials such as concrete. The first two projects take on board the idea of spatial extrusion of plastics, rather than printing in layers. Filamentrics is based on a continuous computational method which uses an agent-based algorithm to develop toolpaths in space, in response to a field of forces and specific ideas of structure. CurVoxels uses the same fabrication technique of spatial printing, but changes the computational method to a discrete method based on voxels. While these two projects investigate lightweight, space-frame like structures which mainly operate in tension, the next two projects are based on heavy, wet processes utilising compression-based materials. Microstrata developed a D-Shape like process of powder printing, where sand is solidified with a binder, resulting in heavy, strong, sandstone-like blocks. The next iteration of that project, Amalgama, replaces the sand for actual concrete. A powder based support bed is used to support layers of extruded concrete, allowing for more formal freedom, such as large cantilevers.

CONTINUOUS COMPUTATION

Filamentrics

Filamentrics (Zeeshan Ahmed, Nan Jiang, Justin Yichao Chen, and Yiwei Wang) investigated spatial 3D printing of space-frame like structures with a high degree of differentiation. The project is based on a 3D version of a classic FDM (Fused Deposition Modelling) process. Instead of printing in layers, hot plastic is extruded along a vector and cooled down with cold air to solidify quickly in space. There has been a number of precedents for these kind of processes, mainly with small scale 3D printers. The G-Code or machine input is modified by the designer to work in three dimensions. This process was first brought to a robot for the project Mesh-Mould, by Gramazio Kohler at the ETH/Future Cities Lab in Singapore in 2012. An FDM-like extruder is attached to a robotic arm, and used to extrude a mesh-like structure which is then used as a formwork for a semi-liquid kind of concrete.

Filamentrics aims to 3D-print heterogeneous space-frame like structures, where material is organised according to principal lines of stress. The material organisation also responds to
other types of structural data such as the amount of stress. To achieve this heterogeneity and adaptability to structure-data, an agent-based system was used. Principal lines of stress are translated as a vector field, which can be implemented and read by a series of agents. While maneuvering the vector-field, the agent creates a toolpath trajectory for the robot. The agent gets a series of constraints which relate to the constraints of the fabrication process. For example, it’s prevented to self-intersect with existing lines. A minimum and maximum distance between trajectories is also constrained. In a subsequent stage, a second set of agents connects the previously generated lines together. These triangular connections are again subjected to a series of constraints. The lattice-like structure in between lines is constrained by a specific angle under which the nozzle would intersect with the deposited material.

The organisation of these trajectories responds to the amount of stress through bundling: where there is a high level of stress, lines start to cluster together. The designed structures are initially generated as a whole, but can then be broken down into designed pieces which fit the maximum workspace of the robot. This process of generation is entirely scripted in a Processing-based applet. Once the structure is generated, it’s exported as a text-file to Rhinoceros/Grasshopper. HAL is used to generate the actual machine code to drive the robot, and communicate with the extruder. As a final output, a 3 x 2.5 x 2.5m pavilion was printed. It consisted of 26 pieces generated by the applet developed for the project.

The generative process takes a number of constraints into account, but the resultant structures still need a large amount of time to solve errors, intersections and singularities. Due to the heterogeneity and large amount of variation in the generated toolpaths, it’s difficult to automate the post-rationalisation. Problems and errors are, just like the structure itself, continuously different and require unique solutions. This means that the file preparation becomes time-inefficient. The nature of this problem lies in the continuous character of the
Errors can’t be serially solved, and large amounts of time or computational power is needed to prevent them from occurring. The continuous nature and interdependency of the agent-trajectories also fundamentally doesn’t allow for a local problem solving. If a problem occurs, the whole system has to be rerun to solve it.

MICROSTRATA

Microstrata (Maho Akita, Fame Ornruja Boonyasit, Syazwan Rusdi and Wonil Son) uses the opposite kind of materials to Filamentrics: heavy, compression based sandstone. The project is based on a powder-printing process, similar to Enrico Dini’s D-shape. A layer of sand is spread out and flattened by a custom made end-effector on the robot. The nozzle itself consists of a needle connected to a valve, which drops binder. The custom-developed software for this research project understands every drop of binder as computable matter. The team adopted an approach based on voxels or three-dimensional pixels, in combination with an agent-based system. In a similar way as Filamentrics, agents are used to distribute and organise a network of connections. In this case two different types of agents are developed, one which reacts to tension and one to compression. This network is then effectively voxelised. Voxels containing compression data trigger the end-effector to deposit binder, whereas tension areas remain empty. The data generated by the processing applet is effectively just a voxel containing a boolean statement to open or close the nozzle valve. At a later stage, aluminium is cast inside the cavities left by the tension network.

To give an example, for building an enclosed tension channel, 8 voxels need to be bound together. The size of one voxel or drop of binder is 4 x 4mm. To achieve these types of precise typologies, a Cellular Automata logic is developed, which can expand the initial voxel and form channels or bridges. The compression network develops as solid zones, reacting to amounts of stress. In areas with high stress levels, a thicker cluster of voxels is
Physical prototype – RC4 203-14 // Team Microstrata: Wonil Son, FaFame Boonyasit, Maho Akita & Syazwan Rusdi.

Applet Screenshot – RC4 204-15 // Team CurVoxels: Hyunchul Kwon, Amreen Kaleel and Xiaolin Li.

3D printed chairs – RC4 204-15 // Team CurVoxels: Hyunchul Kwon, Amreen Kaleel and Xiaolin Li.
generated. This process resulted in a series of porous sand-stone structures, connected with a capillary network for tension material.

Compared to Filamentrics, Microstrata employed a less linear and continuous fabrication process. Although the material distribution is continuous, the voxel and CA logics introduce a degree of discreteness in the process. The process of preparing robotic control data in Grasshopper proved to be simpler. The CA logics were relatively efficient at problem solving.

**DISCRETE COMPUTATION**

Taking on board the problems associated with continuous, generative processes, the second iteration of research, conducted during the academic year 2014-2015, focused fundamentally on discrete computational processes.

CurVoxels (Hyunchul Kwon, Amreen Kaleel and Xiaolin Li) continued the spatial printing research from Filamentrics, but focused on a voxel-based combinatorial logic to generate the toolpath. The team continued the development of the plastic extruder initiated by Filamentrics, adding higher torque motors and a better cooling system. A combinatorics algorithm is used to aggregate a single curvilinear element into a continuous, kilometres-long extrusion, which allows for an uninterrupted printing process.

An initial shape is voxelized, taking structural forces as a driver for the distribution of voxels. The size of the voxels changes in response to the amount of stress, distributing different material densities. When voxels are very small, the embedded spatial curve effectively becomes no more than a line. What appears to be two different formal syntaxes, curvilinear versus linear, is actually the product of a single spatial curve on different scales. The system works by calculating tangents and points of connectivity to other voxels from the curve of a single voxel. Each discrete voxel unit has 24 possible rotations, which enables it to generate a differentiated, heterogeneous pattern. Converting a curve into a discrete voxel unit enables quick evaluation of printability with a high level of control over patterns. The fundamental advantage of this serial approach is that a toolpath only has to be optimised and tested for one voxel, in 24 different rotations. Afterwards, thousands of these voxels can be aggregated, but the connection problems remain finite and manageable.

**AMALGAMA**

Amalgama (Fran Camilleri, Nadia Doukhi, Alvaro Lopez Rodriguez and Roman Strukov) develop a project based on the agenda of printing compression based structures. In this case, the fabrication method combines two already existing concrete 3D printing methods: extrusion and printing. This combination of techniques has given rise to a form of supported extrusion. Concrete is extruded layer by layer over a bed of granular support material. Due to the support, the resulting extruded concrete is of a much higher resolution, and large cantilevers are achievable. The supported extrusion method developed by Amalgamma gives designers more formal freedom and less constraints, while introducing more variation in, what is traditionally, a layered concrete extrusion processes.

The team also developed a combinatorics-based code, where every voxel has a specific type of pattern inscribed on its face. The voxels rotate into a position which establishes a continuous pattern. In a second stage, this two dimensional pattern is grown into a three dimensional volume with a smaller kind of voxel. In a last iteration, these small scale voxels are assigned a discrete part of the toolpath with a random start position. These discrete pieces of toolpath are then connected into the longest continuous line possible, within one layer of the structure.
NEX T STEPS

RC4 engaged for a cycle of two years with the idea of 3D printing large scale structures. The third iteration, which is ongoing, investigates the advantages of shifting to a discrete fabrication method, rather than a continuous one. 3D printing can be considered a continuous method, as it continuously glues or melts particles together, with an infinite connection scheme. Continuous fabrication processes have intrinsic problems with fundamental issues such as speed, structural performance, multi-materiality and reversibility. Discrete or “digital” fabrication processes are based on a small number of different parts, having only a limited number of options for connecting together. The design possibility, or the way how elements can combine and aggregate is defined by the geometry of the element itself - which leads to a “tool-less” assembly. The geometry of the parts being assembled provides the dimensional constraints required to precisely achieve complex forms.

Aligning discrete computation with discrete fabrication, enables the designer to bridge the gap between the digital and the physical. Digital Data is the same as physical data. The physical organisation of matter becomes “digital”, in the sense that it maintains its discreteness and the potential to be re-assembled.

Discrete fabrication has the same type of advantages in terms of problem-solving as discrete computation: problems are serialised and solutions therefore become repeatable and cheap. The fundamental problem of 3D printing lies in multi-materiality: a process of voxel-assembly can deposit infinite variations of material. Rather than using robots as 3D printers, this next phase of research uses robots as voxel-assemblers or voxel-printers. robots quickly pick and place discrete bits of matter, assembling it into heterogeneous aggregations.

FROM CONTINUOUS TO DISCRETE

The research in the first year or RC4 research started out with design methodologies based on continuous computational systems such as agent-based algorithms. These were used to simulate the deposition and organisation of material in space, a process which is then translated to the robot. This workflow led to a few observations: the translation from a continuous system to a set of toolpaths for the robot is often very time consuming and still needs post-rationalisation. The continuous systems become increasingly computationally expensive. To incorporate all the constraints from the printing process in a continuous toolpath requires heavy computing and a large amount of memory.
These observations have led to a shift towards discrete computational methods in the second year of the research, focusing on computing discrete parts of the toolpaths. These are first generated in one voxel, where all the constraints are optimised and tested. In a second stage, a large number of voxels are combined together into one continuous path. This method only requires local computation, and is as such computationally inexpensive and quick. The prototyping aspect also becomes much quicker, as only one voxel has to be checked for problems. Rather than continuous differentiation, heterogeneous structures were achieved by always rotating the piece of toolpath contained in the voxel into different positions. These discrete approaches prove to be successful. The serialisation of the discrete toolpath patterns means that there is a reduction of unique problems to solve. One fragment of the toolpath can be optimised, and then serially repeated and combined into a larger toolpath. Continuously generated toolpaths have a complicated and large amount of unique connection problems, each of them requiring a different solution to become a printable structure.

To overcome the risk of generating rather homogenous structures due to the serial repetition of voxels, the idea of combinatorics was used. Through continually rotating the discrete element in different positions, highly heterogeneous and differentiated structures became feasible. This is a fundamental shift in digital design thinking: from mass-customization and continuous differentiation, to discrete, serially repeated systems which can still maintain a high degree of heterogeneity. This approach not only brings the feasibility of printing digitally intelligent structures a step closer to reality, but also makes 3D printing more accessible. As problems are serialised and easy to solve, there is no need for expensive problem solving equipment such as advanced sensors, camera trackers or supercomputers.
REFERENCES


Khosnevis, B., Contour Crafting, University of South California. [online] Available at: <www.contourcrafting.org> [Accessed 7 Jan 2016].

Malé-Alemany, M., FABbots: Digital Fabrication on-site. [online] Available at: <https://fabbots.wordpress.com/> [Accessed 7 Jan 2016].


Cranfield University, 2013. Revolutionary 3D metal production process developed at Cranfield. [online] Available at: <https://www.cranfield.ac.uk/About/Media-Centre/news-archive/news-2013/Revolutionary-3D-metal-production-process-developed-at-Cranfield> [Accessed 7 Jan 2016].


Schwarz, T., HAL Robotics ltd, 2015. [online] Available at: <http://www.hal-robotics.com> [Accessed 7 Jan 2016].

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WORKSHOP: Framing your live project within a design research methodology

Jane Anderson, Oxford Brookes University, UK
Ruth Morrow, Queen’s University Belfast, UK

ABSTRACT

In architectural Live Projects (also known as Design Build, Service Learning, Extension Projects, 1:1 Projects), students and academics work with external organisations and communities to generate projects. This enables investigation of the experiential, technical, ethical, social, political, economic and cultural implications of architectural design decisions in ways that are not possible in the conventional academic design studio or commercial architectural practice.

Architectural Design Research methodologies offer possibilities for live project educators to tap the research potential of their work. As defined by Fraser, in this methodology “architects use the creation of projects... as the central constituents in a process which also involves... more generalised research activities” (Fraser, 2013).

Live Projects and Design Research are both relatively recent innovations in the discipline of architecture. This workshop explores their potential to work together to create innovative and authentic research outcomes and enrich the learning and research derived from live project activity.

HYPOTHESIS

1. Architectural live projects are an emerging method to generate innovative and authentic research findings with impact that cannot be achieved via conventional means.

2. Architectural live projects deploy research-led, trans-disciplinary, co-design, not-for-profit negotiated methodologies that are alternative to those used by conventional architectural, urban and spatial practice and research, particularly in response to urgent issues such as sustainability, scarce resources, ethics, wellbeing and vulnerability (Anderson, forthcoming).

WORKSHOP OBJECTIVES

The objectives are to explore design research methodology as a means to unlock the research potential of live project activity and outcomes. The workshop will draw upon examples from the workshop leaders’ live project experience. It is aimed at live project initiators, educators, researchers and collaborators who wish to expand their current understanding of research within a Live Project context.
WORKSHOP STRUCTURE

1. Case study presentation: a spectrum of case studies from the Live Projects Network (Anderson and Priest, 2012) and current live research projects running at Queen’s University Belfast will be discussed in relation to the different research activities and outcomes that they have produced.

2. Question for workshop participants: What research emerges from your Live Projects? Subsequent questions to be posed during a whole group discussion: What research methodologies could you employ? Is there a conflict with required teaching outcomes? What potential do Live Projects have for innovative research?

3. Drafting up research objectives for future Live Projects: “Design research should never be something that just happens at the beginning of a project” (Fraser, 2013). Using this model of design research as a continuous activity, working in small groups, what other potential research outcomes can you identify from your Live Project?

DISCUSSION

In architectural live projects, students and academics work with external organisations and communities to generate projects (also known as Design Build, Service Learning, Extension Projects). These transformative projects bridge the gap between research and practice (Dodd et al., 2012), ranging from urban masterplans and design strategies to prototypes and completed buildings.

Live projects are transformational and respond to diverse challenges such as innovative construction for impoverished rural communities, participatory design and informal settlements. Despite the innovation of these projects and their sound basis in the latest inter-disciplinary academic and practice expertise, most scrutiny has been given to their pedagogical and material benefits for students and communities. (Harriss and Widder, 2014)

Architectural live projects straddle education, research and practice boundaries with academics, students and external collaborators undertaking real projects in the real world. Live projects create new ways to generate, test and apply research in authentic contexts, yet these benefits to research are not widely recognised (Dodd et al., 2012).

This workshop aims to identify live project research methodologies and territories, stimulating their potential for innovation, authenticity and expansion of existing definitions of research. This workshop operates within a context where not only is this potential unrecognised among many live project participants, but where the closest field of research, architectural research by design, is being contested in terms of methodology and external recognition (Fraser, 2013).

The ambition of the workshop is to facilitate live project educators in the expression of their work as research in a way that is recognised by research assessment structures, stimulating recognition, quality and dissemination of live project research.

SIGNIFICANCE

Live Projects and Research by Design are both recent innovations in the discipline of architecture (Benedict Brown, 2012). Architectural design is suited to both research by design as well as the more established scientific, humanities, social sciences and text-based research methodologies. Architectural researchers must become expert in these multiple methodologies and must wrestle with all the difficulties of internal and external recognition.
that this brings (Fraser, 2013). This can create negative consequences when work is being peer-reviewed by those with expertise in different or conflicting methodologies. The situation becomes critical when systems (Research Excellence Framework, REF in UK, Excellence in Research for Australia, ERA, tenure track in USA) are created to measure research excellence across disciplines as a means to rank and fund research. Rather than a barrier to development of research in the field of live projects, this situation presents an opportunity to identify and devise relevant and innovative research methodologies. Findings will inform architectural research in general and live project research in other disciplines too.

REFERENCES


2.1.
Design Build Exchange. Available at: <http://edbkn.service.tu-berlin.de/edbkn/?q=node/395>

BIOGRAPHIES

Jane Anderson is an architect and Programme Lead for Undergraduate Architecture at Oxford Brookes University, UK. She runs OB1 LIVE, a programme of live projects designed by students in the School of Architecture in collaboration with local community clients. She is co-founder of Live Projects Network (www.liveprojectsnetwork.org), an online international resource for academics, students and clients. She is the author of Architectural Design (2010), has written on live projects and pedagogy in the journals Charrette, JEBE and contributed a chapter to Architectural Live Projects: Pedagogy into Practice. (Harriss and Widder, 2014). She is a National Teaching Fellow.

Ruth Morrow. As a student Ruth learned though live projects, and throughout her career has taught through live projects. She established the live project, Street Society, in Queen’s University Belfast in 2009 as a one-week pedagogical event involving 1st year undergraduate and 1st year postgraduate students. In March 2016, having been framed as a research project, funded by the Strategic Investment Board and the Dept of Culture and Leisure, Street Society, will draw UG, PGT and PhD students from architecture, music and anthropology to respond creatively to community generated briefs in five critical urban areas in Northern Ireland. Ruth is Professor of Architecture at Queen’s University Belfast.
WORKSHOP: How computational agent-based models trigger creative insights into architectural and urban design education

Kinda Al Sayed
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ABSTRACT
With the increase in the complexity of built environment systems, computational modelling has become an integral feature in the design process. Teaching design computation offers an opportunity to explore the boundaries between designers’ form-finding rationale and how computational decision support systems might contribute to the analysis and synthesis of designs. This paper reflects on these processes, and offers some insights into the use of cognitive agent-based models in form-finding and decision-making, both on an architectural scale and an urban scale. Following this logic, a bottom-up approach in design and decision-making is conveyed through experiential object-based learning, and through the use of computer-aided design tools. In the context of hands-on workshops, participants are introduced to simple mathematical rules of agent-based modelling through group activity. The mathematical rules are devised in design exercises that involve both form-finding techniques and decision-making processes. A design experiment starts from simple principles of how human-like agents might move in a layout setting, to explore how this movement builds up into aggregate patterns that shape built form. The aim is to regulate and externalize decision-making during design in order to reveal how designers’ internal reasoning might influence potential user behaviour in a designed environment. The innovative dimension could be explored through introducing creative variations on design outcomes that satisfies a maximized correspondence between users and the spatial form that envelopes their activities.

INTRODUCTION
Architectural design can be considered as a practice of human cognition in which designers retrieve information from the material environment and reconstruct this information into built form. In this process, designers may retrieve information from built artefacts, from previous designs, or possibly from nature. The utilization of knowledge and experiences into design might involve many domains, including; engineering, arts, computation, cognition, economics and technology. This makes the subject of design a fertile ground for speculations and experimentation. Of interest is how designers’ decisions might influence user behaviour in buildings and in urban environments. In architectural education, there seems to be a divide between analytical
approaches in built environment research and experimental design-centred approaches. Research-centred approaches in architectural education present a top-down view of the built environment, its performance and its social habitat. The focus is often on building quantitative and qualitative models of how buildings and cities operate, rarely accounting for how analytics might be adapted as an integral feature in design rationale. The nature of design process might also play a role in defining the relationship between the subjective intentionality of a designer and the constraints defined by objective knowledge, seeing that design-ners, unlike researchers, tend to be selective about when and where knowledge might be incorporated in decision-making. Designers can have different preferences about the criteria they reason with. While the criteria might be determined partially by the design problem; background knowledge might also play a non-trivial part in shaping the design course of actions. This in itself is presenting a problem, given that for a design to satisfy different criteria it must involve different types of knowledge in different capacities. Unlike research-centred pedagogies, design-centred approaches would be more focused on the experiential part of learning. Designers are often sceptical about aligning their work to a normative pre-determined approach, given the difficulty in accounting for all the variables that make designs possible and the specificity of a design brief. There is also the argument that design in architecture relies mostly on intuition and is largely an irrational process, and yet designers do feed information learnt from research-based architectural education to support design reasoning. It is suggested that an awareness of the consequences of design decisions on the social and economic performance of the built environment need to be embedded in architectural design curricula to help bridge the gap between research and practice. A reflective account of architectural education might present an opportunity to verify the fuzzy boundaries between rational and subjective actions in design through observing students’ performance tackling a pre-defined set of design tasks.

In observing design behaviour, it is important to attend to the ill-defined nature of architectural design problems, to be distinguished from well-defined engineering design problems (Simon, 1984). For a well-defined problem, an automated process can be adapted to seek optimum solutions. For an ill-defined problem, designers seek solutions that satisfy certain criteria by means of heuristic methods (trial and error). Due to the uncertain nature of architectural and urban design problems, the boundaries for rational and irrational reasoning cannot be clearly identified. As Simon defines the boundaries between rational and irrational actions in design thinking; ‘bounded rationality’, he grounds his theory on the subjectivity of a designer, and the cognitive limitations presented by a design situation and background knowledge (Simon, 1957). The identification of these boundaries can only be done with extra caution by isolating the logics of a designer, a situation and the external parameters that influence the design.

In this paper, we reflect on students’ performance in four workshops. In designing these workshops, the intention was to externalize the process of decision-making in design and align it to a procedural set of actions that correspond to a sequence of design tasks. We report on the workshops design, the intended learning outcomes, and what we learnt from our observations. The workshops were mostly part of two postgraduate programmes at the Space Syntax Laboratory, The Bartlett School of Architecture, University College London. Some of these workshops were also delivered independently at the University of Sofia.

**SPACE SYNTAX LABORATORY AS A RESEARCH ENVIRONMENT**

The concept of ‘bounded rationality’ presents itself in the pedagogical practice of teaching architecture in higher education. This concept becomes more visible where the
epistemologies of science and art meet, and where there is divergence between analytical and synthetic methodologies. This is exemplified by the varied demands of the curriculum in the post-graduate courses offered by the Space Syntax Laboratory; MSc Architectural Computing (AC) and MSc Spatial Design: Architecture and Cities (SDAC), at the Bartlett School of Architecture, UCL.

The MSc AC was founded over the last decade. It offers a place where creative approaches towards architecture are explored through computation. Teaching on this course entails exposing students to a wide range of scientific theories and knowledge paradigms. Over the years, this mode of teaching and learning has proven to be a very challenging task given the diversity and intricacy of the subjects in this domain. The main challenge comes from the fact that within one year students transform their state of knowledge and their design practices from qualitative descriptions and passive utilization of computer-aided design tools (coming mostly from architecture) to quantitative descriptions and logical reasoning that are enabled through programming and computation. It is in this realm, where a social and cognitive theory becomes vital to explaining the nature of design and the nature of architectural artefact. Whilst such theories are embedded in the curriculum of the MSc AC, the programme opens up opportunities to explore other interpretations and representations of built form.

Over the last three decades, the MSc SDAC was directed towards outlining and testing an analytical theory; namely that of Space Syntax (Hillier and Hanson, 1984). Students who successfully apply to this course enter a specific type of “community of practice” (Lave and Wenger, 1991); that is the Space Syntax community. Research within the framework of Space Syntax outlines a knowledge-based model that interprets the architecture of buildings and cities sociologically, as agents of social reproduction. The course has a history of evolving pedagogies and has succeeded in establishing a unique culture of architectural research into the science of architectural and urban space (Conroy Dalton and Vaughan, 2008). Students on this course come from a variety of educational backgrounds; architects, planners, designers, anthropologists and others. Depending on their background, they are likely to take different perspectives on Space Syntax; whilst maintaining a shared identity as a community of practice in their future career. It is thought that a research environment that is bound by a pre-defined framework may induce scientific ‘fixation’. The risk of fixation is high, where predefined theoretical or technical frameworks allow for old theories to frame and influence new contributions. This might be limiting, particularly when facing the challenges of uncertainty in design, hence the need to find pathways for experimentation and innovation in teaching analytical and elaborative models in the context of design.

In 2010, the course changed its agenda to incorporate strategic architectural design and urban design (Al_Sayed, 2012; Karimi, 2012; Griffiths, 2014). This change necessitated new strategies for teaching graph theories as instrumental techniques to aid design thinking. For this purpose, hands-on architectural design workshops are being delivered at the beginning of each academic year and throughout to help architects learn basic mathematical principles of graph theory by applying them in design thinking (Al_Sayed et al., 2015). The workshops are also delivered separately in independent teaching activities overseas (MSc ATC at UACEG, Sofia) to help architects grasp Space Syntax principles more easily. In the following sections, we will explain some of these workshops, the philosophy behind them, and will reflect on students’ performance in the context of a loosely-supervised studio environment.
RESEARCH-BASED EDUCATION TO RENDER THE NON-DISCURSIVE DISCURSIVE IN ARCHITECTURE

Over a period of one academic year, the MSc AC and the MSc SDAC courses present a unique pedagogical environment where architecture is researched and explored on all scales. The theories and methods introduced on the courses are intended to question the architecture of the built form by positioning this in a broader social context. In many architectural pedagogical practices the scientific understanding of architecture is seen to be separate from the art of making architecture. For the courses to succeed in bridging the gap between research and design whilst actively engaging theory into practice, design teaching needs to incorporate a process of knowledge externalization that is open for self-criticism and for external assessment. Knowledge assimilated by students in a “learning cycle” (Kolb, 1984) can be deepened through emphasizing multimodal learning. For that, teaching should aim at engaging mental and physical capacities by exposing students to experiences that stimulate different sensory-motor channels. Within that planned framework, knowledge accumulated from observations can be directly implemented and externalized through visual representations. This externalization would enable a reflective practice in the form of “reflection-in-action” that engages active learning through design (Schön, 1983; 1987).

The knowledge externalization process aims to render the ‘non-discursive’ qualities of architecture discursive. Hillier made this argument with reference to theoretical and explanatory models of architectural phenomena (1996). This argument was verified in the context of architectural design (Al_Sayed et al., 2010; Al_Sayed, 2014a). A follow-up on this approach would be particularly valuable in pedagogical contexts. One might argue, for example, that design progresses from the universal towards the particular following a prioritized structure model. In the suggested model, designers follow a linear pathway from the general whilst gradually narrowing the universe of design solutions in search of a design that satisfies all the requirements [Al_Sayed, 2014b]. It is argued that the presence of an explanatory theory of architecture where designers become more self-conscious of the implications of their actions is key to any sensible design approach. A systemic approach to externalizing design knowledge would consequently ease the assessment of design as a process. With a systematic approach in action, we assume that architects will be more specific when defining the relationships between the spatial components of their solutions and will allow for creative variations on the features of design solutions.

In an approach to rendering the non-discursive discursive in architectural education, four workshops were designed to engage architecture students with cognitive agent-based models through devising a learning strategy that would stimulate mental imagery and cognitive capacities. The workshops were designed to prompt constructive learning through doing, as to facilitate “bottom-up higher order learning” (Biggs and Collis, 1982). Students were guided through a process of experiential learning (Kolb, 1984) where experience, perception, cognition and behaviour are all brought together to leverage a maximised gain of the intended learning outcomes. Following this initiative, students construct knowledge starting from simple principles to form representational models of the physical space. Students were left thereafter to construct different interpretations of the representational models, and utilize elaborative model and analytical techniques to inform design decisions and trigger new forms of creativity. In what follows, a description of the workshops will be made, starting from a theoretical introduction to the methods and tools used in these workshops. We will reflect on the procedural set of tasks that were implemented in these workshops, keeping in mind that the purpose is to direct the course of design without imposing its conduct. After discussing the workshops experience, we will briefly reflect on our observations.
A THEORETICAL INTRODUCTION TO COGNITIVE AGENTS

As an alternative to a representational scheme of architectural and urban space (Hillier and Hanson, 1984), Turner and Penn (2002) developed a theoretical and modelling description of cognitive agents - an elaborative model of automata representing sighted humans. Both Space Syntax and cognitive agent theories aim at predicting and modelling natural movement behaviour (Turner, 2003). Much effort has been invested in teaching Space Syntax over decades (Vaughan et al., 2007; Conroy Dalton and Vaughan, 2008; Al_Sayed, 2012; Karimi, 2012; Griffiths, 2014), however; little progress has been made in teaching cognitive agents.

Unfolding the intricacies of the cognitive agent-based model to architecture students on the MSc SDAC course can be challenging. Hence one needs to follow a specific structure to reinforce the intended learning outcomes ILOs, which are to do with reinforcing the use of elaborative models in design to support decision-making. Such approaches would offer students the opportunity to construct new perspectives on modelling and simulating the social performance of the built environment. The cognitive agent model can be simplified and conveyed starting from the simplest units of representation; that is the grid points that represent permeable spaces in a layout (Figure 1).

Through the use of such methods, students can accumulate a basic understanding of the agent model that would enable them to devise it in simulations and design. To explain the theoretical introduction to cognitive agents, the ILOs as well as the preliminary observed learning outcomes (OLOs) were broken down in Table 1. After the first 15 minutes of the lecture students are presented to a software demonstration on agent simulation to direct their attention to possible applications of the theories they were introduced to during the lecture. Following the lecture, a physical demonstration of how agents move and make decisions is conducted in the form of a hands-on workshop (Workshop 1). The workshop aids students learning by applying the theories into practice.

WORKSHOP1: HOW SIMPLE ELABORATIVE MODELS MIGHT SUPPORT DESIGN REASONING

Following a theoretical introduction to cognitive agents, a hands-on workshop was intended to answer questions that might arise about how a theory on person-space interactions might feed into design thinking and reasoning to reinforce the relationship between potential user behaviour and a designed layout. The hands-on workshop was scoped in such a way as to encourage students to exercise their design experience whilst...
acquiring the basic principles of graph theory and agent-based modelling. The aim was to explore how simple mathematical models might support design reasoning. In doing so, the workshop helped students structure their design thinking by establishing principles and priorities for design reasoning. The urban design task was intended to be an experiential learning process (Kolb, 1984). The experience is driven by a collaborative approach through which students interface with different modes of representation. The phases where representations reflect the direct experiences into abstract manifestation reveal a real-time and context-driven materialization of thoughts into actions. By limiting interaction to the direct environment of the class, we were able to ensure a neutral assessment of

<table>
<thead>
<tr>
<th>Structure</th>
<th>ILO</th>
<th>OLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falsification of previous theories</td>
<td>Question prior knowledge</td>
<td>Students frustrated and frequent questions are signs of engagement</td>
</tr>
<tr>
<td></td>
<td>Be ready to reconstruct new knowledge</td>
<td></td>
</tr>
<tr>
<td>Proposal and inspiration</td>
<td>Reframe knowledge to fit an alternative explanation of a phenomenon</td>
<td>Students understood the difference and were worried about linking to a new theory</td>
</tr>
<tr>
<td>Theoretical ground</td>
<td>Reconfigure the man-environment paradigm</td>
<td>Students were still trying to grasp the new theoretical paradigm</td>
</tr>
<tr>
<td></td>
<td>Replace an AI model by an AL model?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question post-modernism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critic the experiential explanation</td>
<td></td>
</tr>
<tr>
<td>applications</td>
<td>Associate the theory with the application</td>
<td>The interface was attractive to begin with, but occasionally was distractive from the content</td>
</tr>
<tr>
<td></td>
<td>Stimulate thought by demonstrating likely use</td>
<td></td>
</tr>
<tr>
<td>Experiments on intelligent agents</td>
<td>Examine the outcome of evolved decisions</td>
<td>Students did not appear to understand the difference very well between basic, evolved and learning agents</td>
</tr>
<tr>
<td></td>
<td>Examine the outcome of introducing memory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate how learning animats perform better</td>
<td></td>
</tr>
<tr>
<td>Agent mechanism</td>
<td>Comprehend agents mechanism</td>
<td>Two students asked questions about the deep mechanisms of the model indicating a high level of understanding</td>
</tr>
<tr>
<td>And evaluation</td>
<td>Stimulate analogical reasoning by mimicing agents movement during the lecture</td>
<td></td>
</tr>
<tr>
<td>(theatric performance of how agents move was included)</td>
<td>Evaluate the agent performance</td>
<td></td>
</tr>
<tr>
<td>A comparison between agents and network-based models</td>
<td>Distinguish the divergent approaches and theories behind the two models</td>
<td>Students were able to distinguish between the two models, some were more willing to expose, most of them were in favour of what they know already</td>
</tr>
<tr>
<td></td>
<td>Evaluate how -in effect- the two models meet and correspond</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td>Reflect on how the agent model introduces a cognitive dimensionality to Space Syntax</td>
<td>Students were not properly introduced to cognitive sciences in previous lectures so they could not appreciate the contribution of the agent model</td>
</tr>
<tr>
<td></td>
<td>Follow up with reading through the key literature to expand on the subject</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: The structure of the theoretical introduction on cognitive agent-based models, MSc SDAC course
students’ learning capacities at an early stage in the course. The capacity of learning would be described as the depth to which students can reach in their progressive learning from recognizing pre-structures onwards to the making of relational structures [Biggs and Collis, 1982]. This is accounting for the methods of representation and theorization that are particular to the design process.

SETTING THE SCENE FOR A COGNITIVE AGENT PERFORMANCE
The workshop described in this section, is taught regularly on the MSc SDAC at UCL, and is also offered as part of a one week module on the MSc ATC at UACEG, Sofia. In this workshop, participants are asked to arrange their tables in a random way in the teaching room leaving spaces in-between the tables and at the peripheries to allow participants to move through. This arrangement was drawn on a large sheet. A linear network representation of the spaces in-between the tables was then drawn to expose the spatial structure of the void left by the tables. Students were asked to stand at the peripheries of this arrangement. Each student was asked to choose a random path to move through the tables; starting from the point where he/she is standing to a destination of his/her choice. Each time a student chose to walk through one space represented by one linear segment the segment will be assigned a score of one, this number will add-up if another student chose that space again [Figure 2]. After finishing the experiment, the scores that each linear segment hit are summed up. The resulting numbers represented the aggregate movement potentials for that particular spatial segment.

FROM MOVEMENT PERFORMANCE TO MOVEMENT ECONOMIES: AN URBAN DESIGN EXPERIMENT
Following the cognitive agent performance, students were asked to work in groups of four and redraw the spatial structure defined by the table pattern. The spatial structure was to be used to design an urban area as an envelope for that structure; the spatial structure might be considered as equivalent to the street structure. Students were advised to use the scores they have accumulated for observed movement as parametric rules to assign certain land uses and three-dimensional features to urban form. For example; it was suggested that where there are higher records of movement, there is more likelihood
for retail activity, wider streets and high-rise buildings (Figure 3). The design propositions were then presented (Figure 4), and discussed by the tutor and fellow colleagues.

Judging on the design outcomes in Figure 3, it was difficult to tell which design was more advanced, since all designs presented a mature stage of analogical reasoning where abstract descriptions of space became occupied by a more realistic urban context. The design performance might be judged upon the ability of designers to cast their own interpretation of the analysis, to synthesize solutions, to show evidence for creativity, strategic thinking, and to communicate that verbally and visually through their sketches and annotations. Judging upon these criteria, design outcome (2) presented an interesting case where students proposed a typical planning proposal that signifies social segregation and territoriality at its utmost level. This indicates an advanced level of understanding and reasoning. Design outcomes (2) and (3) have also indicated an advanced level of representation where students shifted from a 2D abstract representation of their teaching space to a 3D description of an urban scheme. Design outcome (2) was a materialization of user-centred experience. The verbal transcripts of the final presentation indicated that students reflected upon their user-based experience of an urban environment to support their decisions about where to place green spaces, high-rise buildings, and how to allocate land uses. Design outcome (3) established an original association between the probabilities of movement through a street space and the symbolic presence of certain types of retail brands. In general, the use of graph theoretic and agent-based principles was taken to a higher dimension in the designs proposed by MSc SDAC students to demonstrate associations between realistic urban contexts and abstract descriptions of urban form.

OBSERVED LEARNING OUTCOMES

During the course of this workshop (1 hour in total), students were able to learn principles of:

• Agent-based modelling (Turner and Penn, 2002; Turner, 2003).
• The application of Network theory on urban space; namely that of Space Syntax (Hillier and Hanson, 1984)
• The theoretical and technical framework of “cities as movement economies” (Hillier, 1996)
• Systemic movement traces observation techniques.
• Basic arithmetic and graph theoretic.
• A novel application of the abovementioned theories and models in the realm of urban design.

Beyond the tangible learning outcomes, there are tacit learning qualities that were achieved through this experiment; some are to do with learning in a situated social context and through group work (Lave and Wenger, 1991), learning through doing (design), and object-based learning (Lyon, 2012). It is suggested that by aligning architectural pedagogies to this mode of teaching and learning, it is possible to achieve a “Higher Order Learning”, one that involves creating knowledge rather than transmitting knowledge (Duhs, 2010).

WORKSHOP 2: DEVISING COGNITIVE AGENTS IN FORM-FINDING

The workshop presented in this section was delivered as a computer-aided design approach to MSc ATC students at UACEG, Sofia. This workshop was broken into two phases (figure 4):

• An analytical phase where students were to use DepthmapX software to analyse their designs using visibility graph analysis and agent analysis.
• A simulation and visualization phase where students used both SketchUp and 3D
Studio MAX software to visualize the aggregate movement patterns of the automata (standard cognitive agent analysis).

In a procedural process, students started with an overview of the methodologies underlying agent analysis in DepthmapX. 2D and 3D demonstrations of agent analysis and simulation were offered in a group tutorial context. The tools enabled users to generate different predictions for aggregate movement potentials by controlling the parameters and rules in the toolbox window. The 3D simulation allowed users to view how standard agents move in relation to space. The 3D view helped understanding how individual movement behaviour of standard automata/agents builds into aggregate patterns that might then be compared to human behaviour in space. Following the technical tutorial, students were asked to generate designs for an apartment layout, and run agent simulation to analyse...
Figure 4: The structure of the computer-aided design workshop, including both an analytical phase and a simulation and visualization phase.

### Analyzing design outputs

<table>
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<tr>
<th>Design output</th>
<th>Layout representation</th>
<th>Visibility Graph Analysis (VGA)</th>
<th>Agent analysis</th>
<th>Agent traces</th>
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Figure 5: How aggregate movement patterns of cognitive agents (produced in DepthmapX) were used to produce 3D visualizations using SketchUp and 3D Studio MAX. The layouts were designed by MSc ATC students, Sofia.
their design outcomes. The 2D outcomes of agent analyses were then used to produce 3D Mesh configurations using the “Bitmap to Mesh” SketchUp extension.

The visualization can be thought of as an assistive technology in design, and could be used in form-finding and conceptual design development (Figure 5). Students were able to generate some very interesting variations on the analytical outcomes of agent simulations, quoting Milla Zlatanova and Konstantina Hristova (both students at the MSc ATC course, Sofia):

“Agent-based simulations could be perceived not only as a methodology to explore environment in terms of habitat but also to implement the outcomes in a conceptual development of a project. The graphical representation of movement suggests a substantial source of inspiration. For example, several congested layers of trails with fluctuating parameters would give us nodes and paths to explore and to implement into a future design; a 3D model of the agents’ movement resembles a topography, it could be translated into urban environment or a map of public attractions.”

WORKSHOP 3: HOW CREATIVITY AND EFFICIENCY LINK TO VISIBILITY PERFORMANCE OF LAYOUTS

In this workshop, MSc SDAC students were to assess a set of design proposals for an architectural practice in terms of ‘creativity’ and ‘efficiency’. The judgment is based on their ‘expert knowledge’ as architects. The exercise was scoped to increase students’ self-awareness of what they recognize as ‘creative’ and ‘efficient’, and to test that against potential design performance through agent-based simulations. The experiment was, therefore, intended to increase learners’ self-consciousness of their own judgment criteria and the implications of that on the configurations of their design proposals, attending to how these configurations might restrict or enable circulation and movement in a building layout.

Based on the judgment criteria of six participants, the average scores yielded proposal [g] as the most creative design proposal, marking the highest average ‘creativity’ score (C-score), whilst design proposal number [b] was reported as the least creative (Figure 6). The average efficiency scores (E-scores) presented different preferences; students were more in favour of proposal [c] as the most efficient design. Remarkably, the most creative design proposal [g] came up as the least efficient one.

These results are compared to visibility graph configurations (through-vision analysis) that is basically the look-up table that cognitive agents use to make choices about where move next (Figure 7). It was noted that design [g], which was chosen as the most creative and least efficient design presented lower average through vision values [i.e. spaces in this design are less interconnected visually]. However, design [b] and [c], marking the least creative and most efficient designs respectively corresponded to lower levels of through movement. With that finding, we concluded that the relationship between what students recognized as ‘creative’ and ‘efficient’ designs and the visibility performance of these designs was not discernible.

During this exercise, students developed skills to assess designs both subjectively and through evidence-based methods. It would be interesting in the future to compare their evaluation before and after analysing space. It is thought that through spatial analysis, students will develop better appreciation of the value of designing spaces as opposed to designing solid partitions.
WORKSHOP 4: COGNITIVE AGENT-BASED SIMULATIONS TO INFORM INTERACTION DESIGN

This workshop was part of the “Thinking Networks in Design and Research” project (2012-2013) funded by the Teaching Innovation Grant (UCL Vice Provost Education). Participants came from MArch GAD, MSc Architectural Computing (AC) and MSc Spatial Design Architecture and Cities (SDAC), The Bartlett, UCL. The delivery of the workshop tutorial was supported by a UCL lecturer, a lecturer from the University of Applied Arts Vienna and a number of postgraduate teaching assistants.

Figure 6 Average ‘creativity’ scores (C-scores) and average ‘efficiency’ scores (E-scores) based on designers’ expert knowledge. The scores (1-12) are averaged based on 6 observations; where higher scores indicated lower creativity/efficiency and lower scores indicated higher creativity/efficiency.

Figure 7 Average ‘creativity’ scores (C-scores) and average ‘efficiency’ scores (E-scores) based on designers’ expert knowledge. The scores (1-12) are averaged based on 6 observations; where higher scores indicate lower creativity/efficiency and lower scores indicate higher creativity/efficiency.
EXPECTED LEARNING OUTCOMES
The physical computing workshop took place between the 7-13 of January 2013 at The Bartlett, UCL. The title of the workshop was Demystify-Remystify. Its main objective was to demystify technology by using free hardware, electronic parts, resistive material such as graphite or velostat and various sensors in new and innovative ways, re-purposing electric circuits and learning about re-active art through reverse engineering and rapid prototyping. Above and beyond that, the workshop was to trigger students’ interest in the impact of technology on human cognition and behaviour, in that it incorporated the interaction between humans and installations from a user-centred design perspective. The initial aim of the workshop was to demystify circuits and hidden systems within everyday technologies, the indirect aim was to complement the loop of learning by encouraging students to evaluate the impact of their learning outcomes on environment and behaviour in architectural layouts. This has informed them about possible ways to enhance the usability and attractiveness of their projects.

TECHNOLOGIES AND METHODS OF TEACHING
As part of the workshop, sensors, microcontrollers and actuators were introduced to students. Once a fundamental understanding of these tools was established, students worked in interdisciplinary groups to produce 5 installations which were tested in sites around the UCL’s main campus (Main Library and North Cluster). Most of the installations were associated with library and exhibition objects, both from a spatial and conceptual framework perspective, as the learning objective was to reinforce the relationship between the designed objects and existing elements in the building layout (Duhs, 2011). The final element of experimentation was directed to observe how technologies become part of the social sphere of human experience, and test that through the use of cognitive agent simulations. Thus, students were to explore the relationship between digital and material practices in building responsive environments. They took photos, made documentation videos, observed how the library users would approach their installations and encouraged interactions with their project. With knowledge and experience accumulated in this user testing phase each group designed a poster and produced a short movie, some movies were posted online using the Vimeo platform.

OBSERVED LEARNING OUTCOMES
Students chose locations in the UCL building layouts using the agent-based simulations, in such a way as to maximise the visibility of their installations, and then reported on the observed user interactions with their interactive installations through sketches (Figure 8). As a result of these observations, students became more aware of how spatial configurations might influence users’ behaviour and interactions. They were able to separate the role of different sensory information; light, colour, movement dynamics of the installations, and learn about the temporal dynamics of interactions. Some groups decided to amend their installations, in order to narrate their performance and synchronise it with different scenarios of users’ movement in the immediate environment.

CONCLUSION
The workshops discussed in this paper presented an attempt to devise computational techniques and technologies in design and decision-making. They did so by exposing students to mathematical representations that would inform their design decisions. In this learning process, the level of engagement was evident in the general explorative design trend, and demystified in the learning outcomes. Design originality arose through a systemic and procedural set of actions where a new task is only declared after the completion of the former one. Following this logic, the instrumentalization of knowledge
and past experiences in design thinking was externalized to distinguish between subjective evaluation of designs and rational knowledge-based reasoning.

In what concerns rendering the non-discursive discursive in architecture (Hillier, 1996), the designed pedagogies have led to the following key learning outcomes.

- In Workshop 1, students developed analogical descriptions of urban form and function learning from past experiences and design knowledge and assigned these descriptions to abstract representations of street networks.
- In Workshop 2, students explored how a procedural design course of actions that gradually shifts from analysis to synthesis might be approached differently by each designer.
- In Workshop 3, students explored how an increase in designers’ self-awareness of their judgment criteria - exemplified in how they assess creativity and efficiency in designs - might be related to layout visibility configurations.
- In Workshop 3, students have also become more aware of the value and aesthetics of space design as opposed to designing solid partitions.
- In Workshop 4, students developed an understanding of how digital installations might be embedded in a building environment, and how users might interact with their installations.
In observing design activity, it was proving to be difficult to distinguish between designers’ subjective evaluation and knowledge-based reasoning, despite the effort to externalise design knowledge. The uncertain nature of design might allow for the thought that absolute objectivity is unrealistic. However, there were non-trivial advantages in discursive practices of design thinking that allowed for improved Observed Learning Outcomes (OLOs). It is therefore suggested that embedding such practices in architectural education would help reinforce the research-design loop.

ACKNOWLEDGMENTS

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REFERENCES

Schon, D (1987). Educating the Reflective Practitioner; Toward a New Design for Teaching and Learning in
the Professions, Jossey-Bass Publishers, San Francisco.


curiosity
production
risk
participation
It’s a strange, unsettling and yet exhilarating time to be in architectural education, especially in Africa. Globally, insofar as one can glean from anecdotes and e-mails, the talk is of change, risk, opportunity, shift. Here, in contrast, students are up in arms. They throw sh*t at statues, they set buildings and cars alight and they’ve successfully brought the Minister of Education to his (metaphorical) knees. #FeesMustFall began life as #RhodesMustFall, the campaign to topple Cecil Rhodes’ statue outside the University of Cape Town. He did fall, and fairly promptly, too. But that was only the beginning.

The upcoming AAE conference is framed around four main themes: ‘curiosity’, ‘risk’, ‘participation’ and ‘production’. Each of these has special resonance and relevance in the complex and often contradictory relationship between South African society at large and its built environment. In South Africa, the very idea of a shared culture or values-in-common that might transcend the specificities of place, language, history and ‘race’ remains an ever more elusive pipedream. The question of what and how we might teach our current and future young architects is equally elusive. African schools of architecture have yet to attempt – never mind resolve – the profoundly complex translation of indigenous, pre-European built environment beliefs, histories, relationships and ways of seeing the world into a functioning, relevant and accessible architectural curriculum. One poignant reading of the fervour surrounding the #RhodesMustFall campaign is provided by Ferial Haffajee, the editor of the weekly City Press. ‘Are we simply fighting over the past because of our inability to build a future?’

In her wonderful interrogation of the American literary imagination, the African American writer Toni Morrison speaks of the importance of recognising a writer’s notions of ‘risk’ and ‘safety’, and of being aware of the writer’s ‘sweaty fight for meaning and response-ability.’ Last year, at the University of Johannesburg, embracing such a fight, we began a rather risky experiment. We brought the Unit System to Africa and believe me, that’s not hyperbole. It was fraught with risk: from finding the right teachers to placating disappointed students, sourcing support and funding in unending, limitless measure. In two years, the graduate programme went from 12 to 90 students. It’s too early to tell if it’s worked. There’s a reason why political terms and accreditation visits happen at four- or five-year intervals. Change is a slow, complex and unpredictable business and few institutions will take the risk, least of all a new university in one of Africa’s most problematic cities with its violent history of spatial segregation. But equally, nowhere in the world (at least to me) is the call for ‘new forms of knowledge’ more urgent than it is in Africa. If we’re not in the business of producing new knowledge and taking the odd – or even major - risk, then why are we here?
Code-breaking: curiosity through the critical examination of ‘cultural software’ in architectural education

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ABSTRACT

As computational technologies continue to proliferate in architectural education, from digital fabrication and parametric design to BIM, the underlying socio-political implications of the software used every day by students is rarely questioned. This paper will call for architectural educators and their students to examine where our reliance on software of all forms is leading the profession. Lev Manovich’s writings on new media have exposed how the type of creative software packages we teach students to use, which he terms cultural software, have developed on a trajectory that both simulates and subsequently extends traditional modes of representation. Manovich defines how Photoshop has affected visual tradition, transforming the collage from a radical statement performed through pictorial juxtapositions to the smoothed and blended apolitical imagery we see in the contemporary architectural rendering. Likewise, the proliferation of software for leisure such as social media and videogames and the influence they have on the politics of the user has been discussed in the works of Manovich, Ian Bogost and Alexander Galloway, however not with a specific focus on their meaning for architectural education and practice.

This paper considers the ways in which architectural students can become more curious about the software they use to design, communicate and mediate the city around them, and how they can shape the politics of the profession through this attitude. The paper will introduce a series of case studies, outlining strategies for curiosity through reference to design projects including work produced by students of my studio. One case study involves investigations into popular mapping technologies such as Google Earth, and how the ‘glitches’ within the algorithmic application of photographic textures onto 3D geometry can be seen as a new digital vernacular. A further example will examine the role of Minecraft as a non-specialist tool for architectural design, and question what impact recent movements to use the game for public engagement with city planning processes might have on the profession. Other case studies explored in the paper include the potential role of free game engine software such as Unity3D and low-budget virtual reality systems including Google Cardboard in allowing architects to produce fully navigable virtual spaces and how this provokes curiosity through the enabling of spatial and atmospheric prototyping. The paper will argue that we can use the new media theories of Manovich, Bogost and Galloway to outline design methodologies for students promoting the curiosity to question, reject, or break the software and interfaces they are
typically trained to be proficient in. I argue that despite institutional drives towards the technological ‘cutting-edge’, much of today’s most technically and politically engaged student work will come from those who seek to peel apart the technologies we might dismiss as every-day - our free tools for seeing the world around us, for consuming, generating and communicating pop culture or for creating interactive fictional spaces and stories.

**PAPER**

We can say with some certainty that any architectural student undertaking their education today will at some point produce work using software. Whether or not they choose an institution or studio that aligns itself with ‘computational design’, or instead pursue agendas that privilege say, hand drawing or live-site work, it is highly likely that some form of software will be learned and used in the production of a project. This might be an Autocad drawing for fabrication, a Photoshop visualisation, or the production of a portfolio on Indesign.

These applications are what media theorist Lev Manovich (Manovich, 2013) has termed cultural software – “certain types of software that support actions we normally associate with ‘culture.’”. This software does not necessarily require knowledge of code, and typically utilises a Graphic User Interface (GUI). Yet as Manovich points out: “Given that today the multi-billion dollar culture industry is enabled by media applications, it is interesting that there is no single accepted way to classify them.” Manovich’s attempts to categorise these programs and frame their impact might leave an impression on how we understand the relationship between architectural design and software. What I believe to be key for education is how we interrogate our day-to-day operation as designers today. As Manovich says, this concerns our use of software on many levels:

“Therefore, if we want to understand how software has already re-shaped media both conceptually and practically, we have to take a close look at the everyday tools used by the great majority of both professional and non-professional users – i.e. application software, web based software, and, of course, mobile apps.”

In looking at cultural software we may also be forced to admit that the energy of Internet communities and the creativity of ‘amateur’ designers [if that definition holds] challenges the boundaries of the profession. When the Smithsons (1956) said “But today we collect ads” they positioned themselves in the lineage of Gropius’ interest in grain silos and Le Corbusier’s fascination with aviation. But advertisements were different from industrial technology, representations designed to create impulses in popular culture. The Smithsons declared that architects could learn from the ‘pace-setting’ of the advertising industry and its engagement with ordinary people. Reyner Banham (1981) was similarly documenting the effects of mass produced pop cultural gizmos and media on our landscapes. Contemporary writers and artists such as Douglas Coupland and James Bridle give us some sense of the current situation – Coupland’s Generation X (1996) and pixelated Orca whale statues and Bridle’s blog-cum-art-movement The New Aesthetic (2011) becoming a repository for the collected debris of our digital realms, ironically brought together under one snappy title.

It seems none of these projects were necessarily defining the ‘epochal’ architectural style of our time but were about elucidating links between architecture and technology through everyday technologies that affect most people. Reddit can be a hive of questionable internet culture, and a platform via which the US President can communicate. The virtual city of Los Santos in Grand Theft Auto V can have over 54 million visitors in two years
(Loveridge, 2015) and 48 minute daily cycles. Do we as educators retreat from the intensity and diversity of activities taking place on blogs, feeds and forums, in free paint programs or in videogame worlds - or embrace them, like the Smithsons or Banham would have? By fostering curiosity towards how such cultural software has altered traditional methods and media of architectural design, we can encourage learning that embraces all the contradictions and conflicts of our technological world, rather than aligning ourselves to one camp of ‘digital design’. Drawing from the work of media theorists such as Manovich and Alexander Galloway, and game theorist and designer Ian Bogost, this paper will attempt to outline ways in which we might we encourage the curiosity to question and subvert the tools that mediate our modern cities. To do this I will introduce some case studies of student work that I feel is beginning to ‘code-break’ some of the logics of digital pop-culture and derive architectural agendas from it. These examples would not be considered ‘digital design’ in our typical understanding of the term - instead they peel apart cultural software conditions and discover how architecture might exploit these new situations.

**REMEDIANING REPRESENTATION**

In *Software Takes Command*, Lev Manovich outlines a history of ‘cultural software’. He uses a set of pioneering computer engineers as reference points, in particular the Sketchpad work of Ivan Sutherland (Manovich, 2013) to create “a communication system between two entities: a human and an intelligent machine.” He demonstrates software that first ‘remediates’ existing media (for instance, pen on paper) and then extends its capability (for instance repositioning vertex points along a line in CAD).

CAD remediates and extends the line drawing. Photoshop remediates and extends painterly and drawn effects, as well as photomontage and collage. 3D modelling software encompasses both planes and (in software such as ZBrush) a sculptural process of hewing form from a material, extending into rendering and fabrication. BIM remediates the organisation and interpretation of drawn materials and adds the functionality to quickly export further media from a master model.

Manovich makes clear that we cannot entirely divorce our work in cultural software from history:

‘These new media would use as their raw “content” the older media which already served humans well for hundreds and thousands of years – written language, sound, line drawings, and design plans – and continuous tone images (i.e. paintings and photographs). But this does not compromise the newness of new media. Computational media uses these traditional human media simply as building blocks to create previously unimaginable representational and information structures, creative and thinking tools, and communication options.’ (Manovich, 2013)

Every time a student or practitioner constructs a collaged view in Photoshop, or produces a site map using GIS data, we are utilising programs that take many of their principles and symbolism from non-digital media that came before. But this does not mean they have not changed them irrevocably – becoming tools of “permanent extendibility” (Manovich, 2013). Manovich questions whether Photoshop may have turned the photomontage from a political device into one that smooths over difference, the tool used by architects and students the world over to obfuscate undeveloped parts of the scheme that did not meet the deadline.
To see the seductive images of an end-of-year show or in an international competition is often to see Photoshop wielded in such a way, a texture applied here, a contrast adjustment there, a generic tree or a person smoothed into the context and equalised. But can we encourage the use of these remediating and extending tools in different ways, to reintroduce idea of the rupture as a tactic? Being critical about software is doubly important when we use the same techniques in study or research as in commercial work.

Manovich has previously described virtual “navigable space” as a form of new media, and he holds off committing to whether this is a remediation of physical architecture or not. With the rise of easily obtainable game engine software, the ability to produce virtual spaces has become simpler, with engines able to import 3D models from standard architectural modelling programs. If game engines do remediate and extend architectural space, they do this through logic, physics and rendering systems. But if one makes a building model and uses a game engine for a walkthrough, it will appear differently on Unity 3D, Unreal or Cryengine.

We can also add rules and protocols to interactions in our virtual building that allow us to design the ways the user can engage with it. These are the rules can make arguments that Bogost (Bogost, 2007) terms “procedural rhetoric.” The virtual navigable space allows us to extend architecture through the application of rules and representations directly into it. Clearly the simulated space is a representation in itself. But their internal collapse of the gap between representational rule and experiential space seems to open up new opportunities for design.

With low cost VR technologies such as Google Cardboard we can imagine this enmeshing becoming much more obvious, as one can have a 1:1 equivalent viewpoint into a 3D navigable space. Is there then the potential to ‘inhabit’ a space mediated by representational rules – do game engines offer us the chance to live the drawing?

I would suggest that the future of architectural ‘code-breaking’ might not be in photorealistic walkthroughs, but in students becoming curious to exploit the aesthetic possibilities of videogame space for speculation. By combining the procedural and representational, game engines appear to be the cultural software that may allow us to encode persuasion and politics into navigable space. But if this might be the preserve of new speculative projects to come, what does cultural software currently do to our physical world?
Our conception of the ‘site’ is now under the pull of technologies for the ‘remote viewing’ of space. Student projects and competition submissions sited across the world utilise facsimile versions of the built environment, the spatial information brought to hand through various cultural software. These interfaces are undoubtedly useful, even liberating in the possibilities they offer to traverse and comprehend remote locations. But they are by no means devoid of politics or potential inconsistency. As Mark Dorrian (Dorrian, 2013) argues, if the famous ‘Blue Marble’ photograph of the earth taken by the Apollo 17 astronauts framed the planet as a “single organism”, then the “suturing” of multiple images together into the Google Earth globe – as he puts it – demonstrates a globe under the logic of surveillance imagery and algorithmic processing.

While it may appear architects now have the ability to explore a site from wherever in the world, it is not without its errors. The 2012 release of Apple Maps was accompanied by copious screenshots detailing the glitches that saw freeways melt into hills, monuments become flattened and cities moved hundreds of miles. Sites such as http://theamazingios6maps.tumblr.com/ popped up to document this weird new urban realm of glitch and half-truth. As with much cultural software activity the identification and communication of these errors was firstly through Internet communities and social media users. Through their exposure of the everyday glitch these users opened up new lines for architectural curiosity that question the status of the site itself.

But as these slippages and meshes that take place in software are also clearly sited in reality – are there new hybrid sites with which to engage? Away from the rarefied atmosphere of the pavilion or prototype, cultural software such as Google Earth demands our curiosity because it reframes real places and turns layers of our cities into new sites. As Bogost points out, the algorithm does not work in a vacuum:

“It’s not just mapping software running via computer—it also involves geographical information systems, geolocation satellites and transponders, human-driven automobiles, roof-mounted panoramic optical recording systems, international recording and privacy law, physical- and data-network routing systems, and web/mobile presentational apparatuses.” (Bogost, 2015)

We can see many layers to the real world that are being pushed and pulled by their virtual framing. Rooftops become the primary elevations for architectures viewed by satellites. Dubai already expresses its economic and political hubris through buildings designed to be seen from space. To explore the aesthetics of Google Earth is to question these layers of digital “scrim” (Crandall, 1999) combining with physical sites. This is about new values placed upon our towns and cities by such cultural software. As educators it seems important to reflect that the computational and digital are never isolated from the world they inhabit.

My first case study is an undergraduate student Chiara Barrett, whose work tackled precisely these issues – that our built environment is being mapped and recorded in new ways, and that we, as architects should interrogate this.

Chiara’s research was entitled The Tenets of Google Picturesque, and was produced as part of a project we ran called Facsimile in 2012. We asked students to critique the tools they would use to remotely understand a city and propose modes of engagement from afar before visiting it on a field trip. Her project sought to peel apart the ways in which
Google Earth combined modelled geometry and texture mapping in its three dimensional cartographic representations. As explained by Clement Valla (2012), this combination is automated through a patented algorithm called The Universal Texture, and Chiara’s research sought to unpeel how physical architecture placed into a city may provoke this algorithm into certain behaviours through its design. In this case then, an algorithm used by millions every day as part of a cultural software program is seen as something architecture could react to in physical space, a form of site context.

Studying the city of Los Angeles, Chiara developed a classification system for the different types of glitches that appeared while traversing a representation of the city using Google Earth. As an algorithm applied to representations of cities, she identified how The Universal Texture behaves in certain ways in particular situations, thereby establishing a series of typologies for cause-and-effect scenarios within which an architect might engage.

In one example of behaviour, Façade Hierarchy, [Figure 02], the quality of mapped imagery varied between the size and perceived importance of roadways – main roads had higher quality mapping, producing buildings that had ‘slippages’ between different resolutions across their facades. Taking a house in the Pico-Union district as a case study, she proposed disruptions to one face of the building, distorting and abstracting its joinery and ornamentation within a gap that Google Earth opened through the resolution slips of its texture mapping. Another typology Inside-Out [Figure 03] dealt with how the algorithm appeared to collapse buildings and turn them inside out producing strange interior conditions. And a further study, Vessel Distortion [Figure 04] explored how buildings might react to the precise height and position of the Google Streetview car photographing elevations. In these cases, the behaviour of the Universal Texture algorithm gave Chiara new sites for engagement, that slipped between virtual and the real.

The study trip becomes particularly important, allowing one to judge the situation on the ground and make comparisons with the represented version of a city viewed remotely. Being able to scale and record a site, seeing its cultural and physical context with our own eyes, allows us to remain critical of the mediated versions of reality that we are given by the proprietary systems of Google, Bing or Apple. For a curious student, perhaps there now exists three sites, the real site, the mediated equivalent, and the ruptures or gaps between the two. Of course, the glitches Chiara observed in 2012 have now most likely been smoothed over.
This was not a ‘digital’ project in the conventional sense yet it was predicated on exploiting the gaps between the version of reality we are presented by cultural software and physical conditions - drawing the algorithm out of its isolation and into a context. I believe our role as educators in this process is not to just dispense paradigmatic approaches towards the digital, but encourage a healthy desire to question what we are being offered by ‘progress.’ After all, nothing is free, Google’s cultural software blurs boundaries between consumer and producer further by offering open services in exchange for monetising our personal information.

In Chiara’s case, the exploitation of glitches became a methodology for the production of further projects, designing a governmental building and questioning ruptures between the illusion of transparency and security.

In blurring boundaries between a building and its facsimile, I believe she developed an architecture critiquing Galloway’s (2012) version of our society of control: “Reflective surfaces have been overthrown by transparent thresholds. The metal detector arch, or the graphics frustrum.”

If our perception of physical context has been changed by cultural software, and can offer new ways of thinking about digitality, then the next case study explores how a social context might grow and blur the divide between ‘professional’ and ‘amateur’ architectural practitioners.

CRAFTING COMMUNITY

When we examine how cultural software might affect architectural practice what sources might we draw from? Platforms such as Tumblr or deviantART provide the ability to showcase and transmit designs, being flexible enough to run from a blog of reposted memes to a primary portfolio of work. If cultural software such as Google Earth has given
us new gaps in space to exploit, then online communities may make us question our social context.

My second case study is a Masters Thesis student I supervised, Marcus Stockton, whose study *Importance of the Block: Why Minecraft Matters* (2015) attempted to outline what impact the popular videogame might have on architectural design. Minecraft (Mojang, 2011) is possibly the most well-known videogame in the world, a landscape of colourful blocks where one literally mines cubes of terrain and crafts using particular material combinations to produce a whole range of different built elements.

Its saturated visual style melds generation Y videogame nostalgia with the world of Lego, and has turned *voxelisation* into a trend reflected by cultural software such as *Qubicle* (Minddesk, 2015).

Minecraft has a ‘Survival’ mode that is notionally the ‘story’ where the player must make shelters in order to protect themselves from monsters emerging at night. But it is the free reign to build spaces and construct communities that has elevated it from a small-scale ‘indie’ game into a global phenomenon. Throughout this process the feature-set of the game has grown, as has the user base, and the wealth of its creator, Markus ‘Notch’ Persson. But many of the decisions on the feature set and logics of the game were developed through close conversation between Persson and the Minecraft community on internet forums.

The game spent two years from its initial release in Alpha and Beta as a growing, unfinished product. During this time the community expanded and participated in this testing process, contributing their ideas to the software. As such, in initial conversations with Marcus it became clear to us that the only way he could adequately judge the growth of this game, and its impact on architecture, was through using the websites on which they congregated as a source itself and participate in that community.

Minecraft has a large community exploring the possibilities the game offers as an ersatz architectural tool. As Marcus discovered, it was the second most searched term in Youtube in 2014 (Stockton, 2015), and there is a huge number of people sharing video tips and tricks for building structures within the game. Alongside this, there is a large number internet forums such as *Minecraft Builders Inc.* with complex manuals for the constructions of certain building typologies and strategies for success in exploiting the randomly generated environments that Minecraft provides at the start of the game.

Furthermore, Marcus’ research utilised some of the gamut of freeware programs designed to transfer information to and from Minecraft itself. These modifications extend Minecraft from a game into a cultural software under Manovich’s terms - for reading and writing information. *Chunky* is a freeware program for rendering within Minecraft giving users to the ability to create high quality imagery of their creations from multiple viewpoints. *Mineways* is another program for exporting terrain from the game into file formats for full colour 3D printing. This has since extended into *Printcraft*, which claims to be “the world’s first 3D printing multi-player Minecraft server”. Users can log onto a specific multiplayer server with a landscape cultivated for free building. Here, the cultural software extends into the built fabric of the navigable game space itself: “Build something inside the plot. When you are ready press the PRINT button on the control panel. This will send you model off to be processed and write a web link into the Minecraft chat. Click on this link to open the model on www.printcraft.org.” (www.printcraft.org)
Printcraft is but one collaborative system for the production of designs within Minecraft. Through participating in Minecraft communities and utilising their tools Marcus was able to build a system for categorising different types of behaviour within the community in order to understand how this cultural software worked for them. Identifying typologies allowed him to demonstrate certain approaches or techniques that players adopted in order to create structures within the game, offering insight into what their motives might be. In Marcus’ case, these examples varied from small shacks designed to ward off monsters through to the “Precedent and Mimicry” [Figure 7] of real world structures (Stockton, 2015), and onto huge collaborative cityscapes, “Megacraft” [Figure 8] with their own laws and governments. Played in a first person perspective, Minecraft also relies on elaborate choreographies from the user, for instance jumping and placing blocks beneath oneself to act as a form of ladder. These techniques would be shared, as communities explored the limits of the game together. The locomotive constraints of the virtual avatar present architectural challenges within the game that the community has overcome in many creative ways.

As Marcus discovered, to delve into the Minecraft community was to reveal the game as a popular tool for ersatz architectural design – which he termed ‘Rise of the Amateur’ (Stockton, 2015). While Minecraft’s voxelised world with its procedural generation sets the basis for its material composition - what can be mined - it is the creativity of its user base that has turned it into cultural software proper. Despite no statistical evidence, it is fair to assume that the vast proportion of Minecraft users (numbering over 100 million) are not qualified architects or training to be. What he ultimately found, is a large community of ‘non-experts’ producing structures that are communicated via web forums, YouTube or Twitch with a reach in terms of hits and views that an architect could only dream of. Indeed, a video of the very first build of Minecraft still sits on YouTube with 9.9m views (Persson, 2009).

We can already see Minecraft being adopted as a tool for architects and planners because it provides a very direct way to engage with people. Marcus cited the Blockholm initiative by the Swedish Centre for Architecture and Design in 2013, which used the game to engage with citizens having transcribed the city of Stockholm into the game. (ArkDes, 2014) Or Block by Block where Minecraft developer Mojang collaborated with the United Nations to provide a tool for residents to decide on changes to their villages and towns, beginning with a playground in Nairobi (Mojang, 2012).
It is clear then, that the game has grown and spread into a piece of cultural software that is being applied strategically by architects, but what was so interesting in Marcus’ study from the position of an educator, was the curiosity to look into the emergent communities that effectively helped build the phenomenon in the first place. Within these places, Marcus found all manner of ‘amateur’ creativity taking place – computational pop culture growing into a social and spatial tool.

To turn again to the Smithsons (1956), here we see an incredible ‘pace-setting’ – large communities inventing and extending cultural software in order to use Minecraft as a tool for spatial design, whether or not they fit within the confines of the architectural profession. Marcus produced a thesis through virtual site work and reportage, exploring conditions on the ground so to speak. As educators surely we need to recognise that new generations of architects will be ever more familiar with cultural software and their online communities – what possibilities for creativity they present, how they challenge the notion of expert and push at the boundaries of what architecture might be.

**CARICATURES AND COMMODITIES**

One of the main powers of videogames as cultural software (or product of) is that they twist versions of reality under their rules, and those rules can say something – much as Minecraft’s rules instigated a landscape of free creativity. Ian Bogost argues that all algorithms “take a complex system from the world and abstract it into processes that capture some of that system’s logic and discard others” (Bogost, 2015). For Bogost, videogames are the sole type of algorithms which celebrate the fact they are caricatures, and this is their potential power as a critical tool. Indeed, Bogost himself has written at length in *Persuasive Games* (2007) about how videogame rules promote certain behaviours in players. So if we move on from Marcus’ study of Minecraft as a platform for ‘amateur’ expression – are there other games that students might study for their persuasive qualities, and what it is that a computational caricature might give back to us as architects?

For my final case study I would like to introduce the work of Agostino Nickl which was produced as part of a 6-week workshop entitled *Pressure Drop* in 2015. For Agostino a first interest in the suburban drift of Chicago led to the search for studies or representations of these spatial conditions from which to develop a design agenda. One of the most culturally pervasive but curiously abstracted representations of suburban life - with its economy of mass production and commodification - is *The Sims* by Maxis – a 16 year old series of ‘life simulator’ games. In an autobiographical move, Agostino chose to analyse the original *The Sims* (2000) because it was a game he played as a child, a virtual dolls house for a new generation of architects.

*The Sims* is arguably a consumerism simulator, Sims work to make money, and their happiness metrics are determined by objects placed within their suburban homes. Although we see our Sims day to day lives, we never see the world from their perspective like Minecraft, but from a disembodied ‘god’ view. Watching a virtual life unfold from this close, yet detached view is – as Michael Nitsche (2008) argues – akin to our obsession with reality TV.

If *The Sims* is a caricature of suburban life, then Agostino was interested in how the suburban home and its objects contributed to these metrics of happiness, and how its cartoonish logics may be persuading us towards certain behaviours. In Bogost’s terms, the game is persuading us to make our Sims into productive citizens, who get a better job, to earn more money, to consume more, and repeat. Because this is a videogame it wears its
caricature status on its sleeve (Bogost, 2015). Agostino developed a series of tactics for disrupting its systems – to the extent of exposing them to the physical world.

In order to draw out the suburban logics of Pleasantville, Agostino had to play it. And in doing so, he rediscovered its critical agency and relocated some of The Sims’ persuasive (Bogost, 2007) aspects back into the real world. Through a series of calculations, Agostino revealed that the typical daily cycle of a Sim leaving for work to earn money and returning in the evening to spend it on commodities could be reversed. In fact, self-employment and working from home were more efficient ways to create wealth. He identified garden gnomes as Pleasantville’s most efficient economic activity. Through playing the game Agostino found that a Sim at the maximum ‘crafting level’ could produce 21 gnomes per day, netting themselves an income of $2100.

Gnomes are a serious business. As they also are in the original town The Sims caricatures. On April 17th 2014 the Levittown police logged the theft of a Philadelphia Eagles themed
gnome (Sofield, 2014). With an estimated value of $25 in reality, one quarter of the in-game value, it appears The Sims really has privileged the importance of gnomes to its economic system. As such, his proposal, entitled Permaville, sought to rebalance the spaces of suburbia through collective living predicated on the gnomic economy.

The gnome became emblematic of The Sims’ economy – and ironically it seems, is not too dissimilar to our real working situations. As Galloway (2012) argues: “It is impossible to differentiate cleanly between non-productive leisure activity existing within the sphere of play and productive activity existing within the sphere of the workplace.” This reinforces the fact that technology cannot be separated from politics or indeed frivolity – we might encourage students to marvel at Amazon’s advanced algorithms for picking objects out of a warehouse, but as Bogost (2015) argues, to see how multitudes of people are involved in the chain we only have to look at the world. For instance, the CHINA photography of Edward Burtynsky, or recent revelations about Sports Direct. Having revealed gnome-making as a lucrative profession – Agostino set out to compare this digital caricature to reality, by becoming a gnome maker himself.

Agostino constructed three gnomes to compare with the material economy of The Sims. One was carved by hand from timber, one 3D printed and one CNC machined. [Figure 9] By producing a time lapse film, Reality Check, he was able to relate the rates of production between a handmade object, an object that requires formatting in cultural software in order to be machined, and how quickly a Sim would do an equivocal job. [Figure 10] The gnome becomes an artefact that straddles the digital and the hand crafted, each displaying a different quirk unique to its method of production. He then developed Permaville into a townscape [Figure 11], drawings composed using screenshots from the game - where suburban plots were allowed to develop in different directions according its logic of suburban productivity, a once idyllic landscape overflowing with gnomes. For Agostino, The Sims and its caricature of suburbia gave him a route into a critique of real logics of mass produced and commodified architecture.

If this seemed an ironic application of videogame logic onto a suburban townscape, writers such as Galloway (2012) remind us that it is not so different from reality. Young people in China genuinely do farm gold in World of Warcraft as a new form of networked menial labour. Agostino’s application of the gnome reminds us that cultural software bridges the gap between the computer and the physical artefact, and that there might be embodied symbolism and politics in the objects that emerge through our fabrication machines – if we encourage students to look deep enough.

Code-Breaking
To teach, or study, architecture today, is to be implicitly engaged in the use of software. In the case studies I have shown, I have attempted to outline methods and projects set up to expose other avenues in which technology has had an impact. To ignore the massive changes in popular culture caused by computation, to chase the tail of the ‘avant-garde’, will miss the chaotic, contradictory, symbolic and emergent properties of digital culture today, from software modders to grandmothers on Facebook. Just as the Smithsons were attempting to code-break advertising in order to understand how desire was mainlined into the population, so today we should encourage our students to break their tools, to find glitches between digital and physical and to develop Frankenstein architectures that remix, mashup and caricature.
REFERENCES


06-08: Marcus Stockton, Importance of the Block: Why Minecraft Matters. 2015. Bartlett School of Architecture, UCL.

09-11: Agostino Nickl, Permaville. 2015. Bartlett School of Architecture, UCL.
Palimpsestuous design: Playing with architecture

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“The contrast between play and seriousness is always fluid. The inferiority of play is continually being offset by the corresponding superiority of its seriousness. Play turns to seriousness and seriousness to play. Play may rise to heights of beauty and sublimity that leave seriousness far beneath.” – Huizinga, Homo Ludens (1938).

INTRODUCTION

Play of light, play of shadow, play of architecture... the role of play is part of our enculturation, central to our development as children, and forms a part of our enjoyment of spaces and places throughout our lives. Curiosity, risk and participation are part of this play, structured by the rules of games - from the physical and digital through to the academic lens of ludic architecture. Game design is based on the key principles of intrinsic and extrinsic motivation, with objectives, activities and accomplishments. Given the complexity of architectural education, and the palimpsest of influence and experience embedded in every aspect of the profession, this paper will explore how we can use game design pedagogy as a lens to potentially transform architectural education and practice, and as a tool to encourage curiosity and risk, to educate and inform. A brief summary of key play and game design principles will be used a framework to discuss some historic and contemporary examples of projects for in studio and professional practice.

Why is this important? Because most of our students will have played more games, and specifically video games, than we can imagine. They have a different framework for learning, and through playing games - take risks, receive immediate feedback, and rewards. What does this mean for us as educators? If you begin playing games, following the same principles of design, from the age of six, and continue to play them, more and more and more... the principles of game play can be formative. Recent research, but the UK Education charity Nesta, suggests that game play and game design can both work as teaching tools. Case studies conducted by Nesta, demonstrate the design of games help develop creative and critical thinking, and stimulate higher functioning skills. Critical thinking is developed through the critique of existing and peer developed games, collaborative skills are enhanced when working in pairs, and research skills are developed through the both the type of game and game content and topic, creativity skills in the design, and problem solving skills in working out how to make a game more challenging (Ho, 2013).
DEFINING PLAY AND PLAYING GAMES

Theories of play and games overlap into many disciplines – from a history embedded in behavioural psychology, sociology and cultural anthropology, through to recent developments in computer game design, “gamification” and serious play. Many contemporary researchers looking to define these terms, refer back to the Homo Ludens (1938) by Dutch historian Johan Huizinga, and Man, Play and Games, by Roger Caillois (1958), and these remain a common reference in books and articles on game design.

In Homo Ludens, Huizinga defined play as “a free and meaningful activity, carried out for its own sake, spatially and temporally segregated from the requirements of practical life, and bound by a self-contained set of rules that hold absolutely.” Caillois tested and expanded on cultural aspects related to play, and linked these to the intrinsic qualities of games. Of particular relevance to architecture, Caillois categorized play into two main groups: paida, spontaneous play, and ludus, structured play. These were further subdivided into types of games and activities: “agon”, activity utilizing skill, “alea”, games of luck, “mimicry”, activities of impersonation and simulation, and “ilinx”, play in pursuit of vertigo and sensation. In his discussion on games of skill, Caillois emphasized the importance of risk for the player, and the threat of defeat, without which the game would no longer be pleasing. This included games which consist of the need to find or continue at once a response, which is free within the limits set by the rules. Caillois related these types of games to verbal expressions such as the playing of a performer, or the play of a gear. He states “In fact, the game is no longer pleasing to one who, because he is too well trained or skilful, wins effortlessly and infallibly” (1958). Caillois’ definition of play can be expanded to include aesthetic and experiential qualities of architecture – from delight in concepts, through to play of light, play of shadow, play of architecture.

In their studies on serious gaming, Rodriguez (2006) and Andreotti (2002) analyse the work of surrealist, situationist and avant-garde artists and writers in relation to Huizinga’s concepts of play. The fundamental values of exploratory learning are curiosity and risk taking, through experimentation. The importance was in the act of design by the student or participant, and not in the transmission of skills – in opposition to modern art schools of their time. Play was in the process, and in the experience of the audience, as evidenced in the work of artists such as Asger Jorn and Guy Debord’s Mémoires, dérives and psychogeographies of Paris. Rodriguez suggests that “Playing can be part of the learning process because the subject to be learnt is, at least in some respects, essentially playful. The use of serious games in the learning process therefore illuminates the fundamental nature of the subject being taught.” While it is perhaps easy to see closer historical relationships between play, games and art, the relevance to architecture and urban design is increasing with advancing technology.
In Toward a Ludic Architecture (2010), Steffen Walz explores the importance of kinesis, real or virtual movement, to play. Referencing the work of the Dutch psychological anthropologist F. J. J. Buytendijk, and psychologist Kurt Lewin’s research on play from childhood through to adults, Walz focuses on the to-and-fro movements and rhythm generated in play. With the assertion that in every play situation, time-based space is created by the interactions between play elements, Walz makes direct links to architecture. He describes play as sculpting an architectural and conceptual play space, and this concept is used to analyse architectural and urban spaces. This links back to Walz’s earlier work in Space Time Play: Computer Games, Architecture and Urbanism: The Next Level (2007), which raises the call for contemporary architects to grasp the new typologies of space, emerging from the virtual world, where space, time and play converge.

Balancing between the work of Huizinga and Caillois, and contemporary texts on game design, this paper will work with the following definitions as a starting point for discussing play and games. Play describes fun, meaningful and voluntary activities, which are contained within limits of locality and duration, and can be open-ended or bound by the rules and resolution of games. Games provide players with goals, rules, feedback, participation, boundaries and specific ways of problem solving. The terms “gamification” and “serious games” have been used in recent years to further define the exponential growth of education and commercial game applications. The use of games in architectural education tend to fall under the term “gamification”, or the use of the principles of game design in non-game contexts (Deterding, 2011). The philosopher and political activist Shiv Visvanathan, sets out a clear distinction between games and play, noting that “A game is a bounded, specific way of problem solving. Play is more cosmic and open-ended. Gods play, but man unfortunately is a gaming individual. A game has a predictable resolution, play may not. It allows for emergence, novelty, surprise.” (Visvanathan, 2007).

ARCHITECTURE AND GAME DESIGN – OVERLAPPING PEDAGOGIES

A typical thirteen-year-old today, could be considered an expert at computer games, playing between 4-10,000 hours, by the time they reach University. Immersion in a game realm of risk, reward, exploration, experimentation, consequences and immediate feedback has the potential to change expectations in the real world (McGonigal, 2011). These expectations are also filtering into education. It is not only architecture students developing these expectations, but clients too. How are we, as educators, researchers and practitioners, adapting to these culture changes? How can play and game design and theory inform architectural education and practice? – and what are the possibilities for the future?

One of the most striking differences between textbooks on game design and textbooks on architecture, is the importance of research in cognitive and behavioural psychology as a starting point for game design, followed by demographics and consumer research. In the standard game design text, 21st Century Game Design, authors Bateman and Boon use demographics and Myers-Briggs Dichotomies to define user groups and target markets, and Flow and Temperament Theory to introduce students to the fundamentals of game design. The overriding factor for the successful game is motivation and engagement, or what is often referred to as “flow”.

Direct links to psychology and game play come from the work of the Hungarian psychologist Csíkszentmihályi’s work on the concept of “flow”, or optimal experience. In “flow” an individual could feel complete, with an energized focus on an activity, with enjoyment and
fulfilment. Csíkszentmihályi considered the lack of design and consideration of “flow” in education, work and everyday environments as a social failing. Csíkszentmihályi wrote “Games are an obvious source of flow and play is the flow experience par excellence,” and considered the lack of “flow” in education, work, design and everyday environments a failing of modern society (Csíkszentmihályi, 1975; McGonigal, 2011).

Malone suggests that instead of viewing intrinsic motivation as an absence of reward, it can be seen as a positive need for competence and self-determination, a search for psychological incongruity, and the experience of “flow” (Csíkszentmihályi, 1975). “Flow” is the channel between anxiety and boredom, achieved through immersive experience. Csíkszentmihályi identified the following common traits for the experience of “flow”: an activity which is achievable and/or can be completed, focussed concentration, clear goals, direct feedback, sense of effortless involvement, sense of control of the activity, and an experience of altered time. Of particular note is the need to present clear goals (and in game design clear short-term goals) and providing feedback as properties of the activity. Case studies show that a desire to know what one is expected to do is a common trait among all players, but is not always the case that the goal if the main source of motivation (Bateman and Boon, 2006).

While goals in themselves can be the source of motivation for activities, the enjoyment and fun of both learning and game play are often linked to extrinsic and intrinsic rewards (Deci and Ryan 1985). Self-determined learner behaviour can stem from both intrinsic motivation (i.e., students engage in an activity because it is interesting or enjoyable) and from extrinsic motivation (i.e., students engages in the activity because they desire a specific outcome and value it as important).

Extrinsic rewards may come in the form of points and scores in games, or provisional marks and positive feedback in studio. Intrinsic rewards relate to the sense of personal achievement and ideally enjoyment, supported with elements of challenge. Most models for educational games emphasize intrinsic motivation, and focus on motivation to perform tasks coming from participation itself (Malone, 1980). In his early work on the cognitive psychology and learning with computer games, Thomas Malone (1980) proposed that the primary factors that make an activity intrinsically motivating are challenge, curiosity, and fantasy. Although extrinsic rewards can be less effective than intrinsic motives, both intrinsic and extrinsic motives play a role in determining learner behaviour.

Drawing on the work of Csíkszentmihályi, many of the texts on game design start with the key principles of goals, rules, feedback and participation, and game design theory expands on how these relate to behavioural and cognitive psychology. In the influential computer game design book Reality is Broken: Why Games Make Us Better and How They Can Change the World (2011), Jane McGonigal explores these principles to explain the potential power of games to change real world issues. Goals provide a sense of purpose, which is both achievable and yet challenging enough to focus players’ attention. The rules set the boundaries and lay out potential routes for problem solving, and feedback lets players know how close they are to achieving their goals. Participation is voluntary – and ideally engaging, so that “players knowingly and willingly accept the goals, rules and feedback”, establishing a common ground for groups to play together. There are parallels with writing studio design briefs and learning outcomes, and to an extent these principles can be overlaid onto the concept design brief or architecture proposals.

The principles of game design are clearly set out, and it is important to note they do
not specifically include rewards. The motivation to play must be inherent in the design of the game, goals and feedback. McGonigal explain several key principles, which by understanding how games work, may help us understand what our student expect in terms of feedback.

• “By removing or limiting the obvious ways of getting to the goal, the rules push players to explore previously uncharted possibility spaces. They unleash creativity and foster strategic thinking.

• The feedback system tells players how close they are to achieving the goal. It can take the form of points, levels, a score, or a progress bar. Or, in its most basic form, the feedback system can be as simple as the players’ knowledge of an objective outcome: ‘The game is over when…’ Real-time feedback serves as a promise to the players that the goal is definitely achievable, and it provides motivation to keep playing.

• Knowingness establishes common ground for multiple people to play together. And the freedom to enter or leave a game at will ensures that intentionally stressful and challenging work is experienced as safe and pleasurable activity” (McGonigal, 2011).

Although McGonigal referred to Tetris in her book, these principles can be poignantly demonstrated if one thinks about Candy Crush. As you successfully align the candy pieces, you get three kinds of feedback: visual—you can see row after row of pieces disappearing with a satisfying poof; quantitative—a prominently displayed score constantly ticks upward; and qualitative—you experience a steady increase in how challenging the game feels. In the three dimensional world of Minecraft, players visually see their structures take form, they quantitatively achieve challenges, find materials and survive, and in a survival mode can meet greater and greater challenges.

As we reflect on the successes and shortcomings of architectural education, the parallels with game goals, feedback and flow are prescient, and have clear relationships to the work of Donald Schön, and debates on experiential and constructivist learning styles (Lainema and Saarinen, ). The use of educational games or the integration of “gamification” concepts, is developing and changing rapidly. A quick internet search on “gamification” will reveal a growing industry of online educational game companies, offering to instantly provide or develop projects for schools, universities, industries and professions. What is surprising is the low profile and/or absence of architecture in current debates on educational and serious gaming discussions.

PALIMPSESTOUS DESIGN – GAMES FOR ARCHITECTURE

The following case studies have been chosen to demonstrate how games and game theory have been used in architectural education and practice – implicitly and explicitly. There are many potential layers to the use of games in architectural design – from the technical through to the aesthetic. The game of architecture lies not only in the design of the building, but in expectation of conceptual engagement and rigor, cultural, social and environmental considerations – what I have termed “palimpsestuous design”. Given a brief to design a music studio, a first year student who designs a building which looks like a guitar will fail in a studio review, but a building designed to use the concepts of a guitar – experientially, aesthetically, materially and/or technically, is far more likely to receive positive feedback. Is this because the student developed a more refined game for the audience? Or because the student is able to play the game of architectural education?

The development of digital and online games for architecture is rapidly developing, from Minecraft and SimCity, through learning engineering principles in games like
PushmePullme and Catastrophe by Expedition Workshed. These are being developed in parallel with immersive and collaborative games for sustainable development and crisis management, like those being used by the Red Cross and Red Crescent Climate Centre. There has been significant press on the use of Minecraft and Lego in design contexts, and current research on the use of these incredibly popular game tools in education is already beginning to shape the future of games as pedagogic tools for learning. The philosopher Bernard Suits (1978), wrote, “Playing a game is the voluntary attempt to overcome unnecessary obstacles,” which has resonance with the design of architecture. I have chosen the following case studies to demonstrate games outside of the contemporary commercial sphere, with the aim to open future discussions on more implicit use of games, “gamification”, game pedagogy and game theory in architectural education and practice.

IN STUDIO

Most architecture students will experience the use of “gamification” – through scenarios for learning, from design project briefs, through to contract and professional practice situations. By reframing studio exercises through game design principles of goals, rules, feedback and participation, we have the potential to use these tools more effectively in our teaching, and enabling our students to use these tools in their designs.

Starting with the simple game of dice, we can engage students with the language and concepts of architecture. The use of dice, as a tutorial device, questions the expectations of students and the role of tutors, while exploring common student design issues, and the varied interpretation of architectural dialogue. The dice are what Caillois referred to as “alea”, games of luck, with the potential to include “mimicry” (Caillois 1958). Both the making of and the playing of the dice offer interesting educational opportunities. The interpretation of the dice, or feedback, can challenge the user to consider issues of intention, hierarchy and interpretation of their rules of design.

First and second year students at the University of Portsmouth analyse a series of iconic buildings as a method of exploring and understanding design principles. The Dissection Project– a three-week exercise in Year 2, engages small groups of students in the analysis of iconic buildings. The first phase is to work as a group to research
and identify strategic design motives and/or constraints, and building a scale model of the building and site, which through its materiality or construction (of the model) reflects these concepts. The second phase is for individual students to analyse and unpick the palimpsest of design considerations – a treasure hunt, and a game of skill. Although the project was not explicitly designed as a game, one can map its success to the use of game principles. Students are given goals (uncovering rules of design used by the original architect), rules (using drawings and models so uncover the layers, rules and concepts), feedback through tutorials and reviews, and participation (extrinsic and intrinsic motivation). Students are introduced to the conceptual design, palimpsest, hierarchy, proportion, site analysis, and context, structural and environmental considerations. While “playing” the dissection in small groups, then pairs, then as individuals – they also strengthen their skills for collaboration, timekeeping, representation and communication.

The 2007 book, *Space Time Play: Computer Games, Architecture and Urbanism: The Next Level* (Borries, Walz & Böttger, 2007), brought together a wide range of academics and practitioners interested in the design and application of computer games in architecture. Now, nearly a decade old, although some of the case studies reveal how rapidly technology has advanced to surpass our expectations, the core discussions on the use of play in the design and experience of architecture are still relevant. Ludger Hovestadt’s essay, *Why Games for Architecture?*, delves into the emergent technologies and reflects on the potential for games, with systems, subsystems and levels to liberate current architectural paradigms, where “the virtual systematically supports the real. The real is systematically enhanced by the virtual. A subdivision is no longer conceivable.” This view of a post-digital world has continued to evolve in research and studios at ETH Zurich CAAD programme. Game Engine, a current elective at ETH headed by Mathias Bernhard is testing the use of game based augmented and virtual reality in relation to client and user experience of space. Although advances in computer aided design, computational design and the internet of things lie outside the focus of this paper, it is important to consider the limited dissemination and trickledown effect of this work to smaller and less technologically equipped universities and schools of architecture. In Ian Borden’s essay, *Tactics for a Playful City*, and Neil Leach’s *Play Stations*, remain poignant discourses on the need to consider play as more than a partner to technology, but as a fundamental aspect of social life. Play holds the potential to reveal humanitarian and egalitarian views, as well as the latent aggression and competitiveness which fuel the development of our cities.

The work of Lindsay Grace and Christopher Totten, at the American University Game Lab, have been exploring the boundaries between architecture and art and computer design through teaching and design across disciplines (Gamelab, 2015). With a background in both architecture and game design, Totten’s thesis and studio projects set students with the task of developing games to explore both the psychology of users as well a tool for generating a brief and design of architectural spaces (Totten, 2008). Totten set up a design project for students using first-person 3D environments as a presentation tool to clients. By structuring the game with horizontally structured teams, and studying the effect of play-based design methods on creativity, Totten was able to test and observe both team dynamics, levels of student engagement and output. Students were able to use the game to design and develop their class projects.
with equal opportunities to make changes. Totten found that “The students reported experiencing more cooperative group dynamics than in the typical studio structure based around having one or two lead designers. They also reported that the relaxation of playing design as a game resulted in a greater pool of creative ideas to work from” (Totten, 2011).

IN TAUGHT COURSES

In the Part 3 Course at the University of Portsmouth, we are using two types of games to deliver and help students revise Part 3 curriculum. This game was developed to provide students with experiential learning opportunities, promoting deeper understanding and application of principles. A scenario based contract workshop is run each year, as a full day immersive game. Students are placed into small “practices” of 3-4 no. students. Their goal is to successfully administer a construction project from briefing through to completion over the course of a day – and to be the first team to complete the contract. The project is run over the intranet, with two tutors acting as real-time clients and contractors, and support tutors helping groups tackle project issues which arise throughout the life of the project. The game requires real-time interaction through emails and completion of instructions and certificates, with a leader board showing progress throughout the day. Rules of the game are set within the parameters of practice and professionalism, project timing, and the construction contract. Students are often in “the flow” of the game throughout the day. Students will go through approximately 20 mini-scenarios through the day, receiving feedback for each scenario before progressing. Rewards come from points on the leader board, achievement and competition, as well as small prizes, like chocolates or book tokens for the winning team. Student feedback identifies this as one of the most valuable experiences of the course, providing the opportunity to engage and experience aspects of contract and practice administration often not open to students. This game is currently a mix of online group dialogue, paper and verbal feedback. We are currently developing a digital version of the game.

Demonstrating knowledge and understanding across the wide scope the ARB Criteria is often daunting for students, and we have introduced a snakes-and-ladders style game to help students with revision. Playing in cooperative teams of 2-3 no. students, the game is a mix of skill and chance, enabling students to work together to answer
criteria based questions in order to roll dice, and move up the board. The questions are practice management focussed, but also touch on other legislation and issues faced in practice. As in practice, there are ladders up (competition wins) and snakes down (unpaid invoices and complaints). This game is introduced as a short workshop in the Course, and like the Contract Workshop, receives excellent feedback from students. Students are able to use the questions and printout of the game in revision sessions outside of the Course. We are currently working to develop a combined version of this game and the contract workshop as an online resource for use in education and professional contexts.

IN PRACTICE

The recent Eames exhibition at the Barbican is a testament to the importance of play and experimentation in design. Charles Eames once said of the work done out of the Eames Office, “We work because it’s a chain reaction, each subject leads to the next.” Play was a creative part of the office philosophy, the creating of products promoting play for clients, the architecture and their pedagogy. The Eames’ House of Cards, the Toy, and ‘Score’ for A Rough Sketch for a Sample Lesson for a Hypothetical Course (1952-53), all reflect their pervasive approach to serious play as a way to reveal and create connections, “the breaking down of barriers that have grown up between fields of learning” (Eames, 2016). These projects bridge between Callois’ paida and ludus, free play and structured play, creating and revealing connections in intention and meaning for the players.

In the 1960s, Buckminster Fuller set out to develop the World Game, which would “facilitate a comprehensive, anticipatory, design science approach to the problems of the world” (Buckminster Fuller Institute, 2015). The purpose of the game, using the Dymaxion map developed by Fuller, focussed on the growing pressures of global population and limited natural resources. Players work cooperatively to world based scenarios, with an emphasis on holistic and cooperative approaches to decision making. Originally introduced for the teaching curriculum at Southern Illinois University, the concepts behind the game and its development became the World Game Institute in 1972.

In its description of the World Game, the Buckminster Fuller Institute, emphasizes
Fuller’s decision to call it a “game”, making it accessible to everyone, and not just the elite individuals in power and politics (Buckminster Fuller Institute, 2015). The game was both about social inclusion and subversion – making data, statistics and information accessible to everyone, outside of political, social and economic hierarchies and boundaries. Conceived before the age of the internet, the World Game that Fuller envisioned was a game where competition and cooperation could be played out to: “Make the world work, for 100% of humanity, in the shortest possible time, through spontaneous co-operation, without ecological offense or the disadvantage of anyone.”

Using computational game theory as a premise for design, Mzo Tarr Architects (Principle, Adam Tarr) have developed a unique approach to brief and concept development in practice. Games, game design and game theory have been used to inspire a number of their projects, from their Tetris House in Chiswick, to the detailed design of interactive installations for Battersea Power Station and Dublin City University (Mzo Tarr, 2015). Mzo Tarr’s website describes game theory as “the mathematical study of decision-making between people in situations of conflict or cooperation.” Using their interest in game theory as a key marketing tool, the practice’s website explains their briefing process in relation to the iconic game of Prisoner’s Dilemma. Two prisoners, incarcerated without evidence for conviction, are offered the opportunity to confess or blame the other and go free. The range of consequences and alternatives, create dilemmas – and flesh out decision making and optimum solutions for complex decisions. Mzo Tarr use similar game related questions and strategies to gather information to quantify requirements and experiential satisfaction. They identify four key ingredients to successful game theory and decision making: players, strategy, information and consequences/payoff (Mzo Tarr, 2015).

CONCLUSION

Architectural education does and can more effectively draw on concepts, principles, processes and techniques from the world of analogue and digital gaming. The use of games for briefing and consultation continues to grow, and is being advanced in the fields of engineering, science, human resources and health care – but there remains limited research and experimentation on the use of games in architecture, analogue or digital. This may be due in part to the fact that the application of games in these fields have clearer or more defined objective and subjective components, and to the strong studio culture in architectural education. The case studies above suggest that “gamification”, game design theory and pedagogy, can be developed to help students achieve and engage in learning aims and objectives across architectural criteria and curricula. In practice, games and “gamification” have the potential to expand conceptual and technical architectural design, and develop client relationships.

There are, of course, controversial aspects to games, and in particular a shift to digital and on-line games over experiential, physical, interpersonal and collaborative working. The efficacy of using games and game design pedagogy in architecture is directly related to their appropriateness, clarity and success in achieving learning objectives and outcomes. In Jesse Sell’s critique of video games for academic learning (2014), he raised the fundamental issue of pedagogic intentions, noting that as educators, “we need to stop looking at games for the content they teach us and instead look at
how the games teach us to learn. We need to focus on what games teach us when we aren’t asking to be taught.” The importance of the game is not always in the content, but can reside in the skills learned to play and potentially win the game. Along with classic pedagogical approaches like Bloom’s Taxonomy, the theory and research into human psychology and sociology which make games fun and successful, can be used to make architectural education and practice more engaging, more successful and more fun.

REFERENCES


rodrigues [Accessed 15 December 2015].
Tarr, Adam, 2015. About the studio. [online] Available at: https://www.mzotarr.com/about/ [Accessed 08 January 2016].
Much of the existing literature surrounding the status of the digital studio, process and production, is focused on its role in the design process and how it is received by the jury during assessment of student work. Complementary to many of the existing studies this thesis aims to evaluate the content and function of architectural graphics within presentation of student work in the academic studio as the tangible artefact and outward expression of student design activity. The aim of this review of literature is to contextualize digitally produced visual architectural artefacts within broader phenomena.

It is important to consider design protocol from both a paper-based and digital position. Although many well-known CAD applications aim to mimic paper-based design functions, the physiological processes are vastly different and therefore may affect cognitive experiences as well. The following empirical studies focus on protocol and cognitive activity during the design process and the approach to problem-solving that is unique to the ‘designerly’ way of thinking. Cross (2001) reviews a selection of empirical protocol studies from the point of view of both paper-based and multi-modal approaches to design activity. Cross’ (2001) survey found that during traditional studio based design activity, where participants were presented a design problem brief and example of typological precedent, advanced student designers appeared to be ‘fixated’ on the example design provided with the brief producing solutions which contain many identical elements from the precedent sample. Thus, suggesting that such ‘fixation’ hinders conceptual design development in preventing the designer from considering all of the relevant knowledge and experience that should be brought to bear on the design problem. These designers may be too ready to re-use features of known precedent rather than exploring the problem and generating new design features and solutions (Cross, 2001). This view is shared by Al-Qawasmi (2005) arguing that the phenomenon goes further and that identity is lost as students begin to design for the global ‘techno-identity’ by not engaging in brief and context specific queries.

A second form of ‘fixation’ discussed by Cross amongst the designers is an attachment to early concept ideas fostering a resistance to progressive iteration of problem-definition and solution. Cross discusses generative reasoning and creative leap arguing that good designers are able to modify their concepts fluently and easily as difficulties are met during the design process and are open to exploration of alternative concepts unlike those with a propensity towards ‘fixation’ and over-reliance on precedent. Suwa
RISK and Tversky (1997; Carter, 1993; Cross, 2001) argue that paper-based design activities facilitate problem-solving and understanding during the design process including ‘generative processes’ introduced by Cross (2001). In particular, paper-based sketching facilitates inference, problem-solving and understanding by encouraging exploration of visually plausible inference solutions (Suwa and Tversky, 1997). Suwa and Tversky point out that traditional paper-based modes are superior to CAD techniques in so far as they encourage reflexion by suggesting that while sketching designers become aware of unanticipated relationships that foster the revision of ideas. Further, Suwa and Tversky bring an awareness to the reader that these ideas are favourable to the current trends of thinking in the cognitive sciences (1997).

The academic studio is embedded in tradition while simultaneously embracing innovation. Therefore, its nature is one of conflict in theory, discourse, and practice. Gore (2006) discusses a way of studio teaching that emphasizes a direct experience with tangible materials arguing that it is the space in which innovation occurs. This practice reflects Cross’ (2001) argument for generative reasoning as students build and rebuild their projects for critical review before an outcome is achieved. Allen (1998) recognizes that speed is fundamental to the rhetoric of the computer and that it is processing speed and not disk capacity that is the limiting factor of CAD applications and, in fact, these physical technological challenges or faults are reminiscent of the modernist ideals of efficiency and productivity contradictory to the postmodern promise of a future fully integrated with technology and a promised to recover what had been destroyed by modernity in the first place. Allen’s anxiety about speed is different but not entirely autonomous from the concerns raised by Cross and Carter drawing on the work of Paul Virilio who distinguishes between the inconsistency of metabolic speed, that of the living being, and the artificial technological speed. The technological speed of the computer is invisible in its working and only visible as an effect. Thus, the computer in the design studio simultaneously provokes extravagant claims and high levels of anxiety (Allen, 1998). Allen views the computer as a tool, with very specific capabilities and constraints, particularly in the studio.

1.

The time-honoured traditions of sketchbook practice are becoming an endangered species within the digital environment of the contemporary academic design studio and professional design office. Increasingly, the manipulation of a digital image acts as a tabula rasa from which a built artefact emerges, a process that is essentially an end in own right, leaving no tracings of the intellectual and creative journey towards such an end. The digital image can be perceived as a fait accompli, possessing qualities intrinsic to its nature which suggest that the built artefact appears as a scripted readymade, materialising as a finished and thoroughly complete object. It is as if the finished artefact has been decided before those affected have knowledge of it, leaving few options but those of acceptance and acquiescence.

The designer’s sketchbook and its contents, by contrast, are a far soupiere, messy affair. At its heart, the sketchbook celebrates and encapsulates the unfinished, the unscripted, and the temporary. Its primary role is that of exploration, experimentation, and the storing up of emerging ideas, one leading to the development of another, and then onto towards yet another idea or iteration. At the core of this process lies a questioning spirit, a will to ask how or why things might be.

Moreover, the sketchbook offers up the possibility of becoming a fluid transient space, since it functions as a gateway through which creative purposes can find their fix in the
world. It presents the designer with an immanent field of potentiality whereby the virtual can find expression in the actual. Between its sheets it channels the virtual – the nearly as – into the world of ideas and artefacts, allowing for the discovery of infinite ascribable possibilities. Furthermore, the sketchbook supports the reclamation of the original notion of ‘virtuality’, being of a kind quite other to the algorithmic ‘virtuality’ associated with digital design technologies.

The contemporary use of the word ‘virtual’ is almost exclusively bound to the domain of digital technologies, its context now synonymous with the digital environments of virtual reality, virtual gaming, virtual friendships, virtual sex, virtual tourism, virtual communities, and so on. By contrast, in referencing Henri Bergson’s theory of duration, Deleuze portrays the virtual as latent potential yet to become or to become actualised. For Delueze, the virtual is as real as the actual, for the ‘…virtual is fully real in so far as it is virtual…’. Indeed, the virtual must be defined as strictly a part of the real object - as though the object had one part of itself in the virtual into which it plunged as though into an objective dimension.’ (Ballantyne, 2007). Essentially, the virtual is in every sense real, though yet to become material.

In terms of design praxis, the activities associated with keeping a sketchbook (as one might do with a diary) make it an effective tool for formulating an alternate mode of design-orientated processes. More specifically, it is an incubator for prioritising the unscripted, the temporary, and the disposable. The sketchbook is modus operandi for effecting an instantaneous, vigorous, and intuitive engagement with the materialization of ideas, concepts, and new ways of thinking. Moreover, such an engagement rekindles the original meaning and significance of the term ‘virtual’ as a central part of sketchbook-praxis, reasserting both the original meaning of the word and its theoretical importance to Deleuzian philosophy.

2.

The possibilities and potentiality of a sketchbook are infinite. Whilst observing its clean pages, it becomes clear that the only apparent restrictions are contractual arrangements formed through personal consciousness and praxis. The latent potential of the sketchbook, coupled to the private nature of the content, draws the practitioner to commit not only their embryonic ideas to paper, but also map out their observations, thoughts and questions concerning the world they operate within.

The empty sketchbook presents its creative user with an untamed, unmapped field of possibilities, a vista into which the designer lays out new pathways and connections as circumstances allow. Overtime this topography is mapped and, as the last page is filled, the sketchbook’s potential may take on a different trajectory as ideas re-emerge, sometimes many years later, becoming further iterations of dormant potentialities awoken once more.

When the integral potential of the sketchbook is comprehended, it provides the user with a limitless horizon of possibilities, a complex, and interwoven mesh of ideas that might emerge, or become, because of the forces at play within it pages. Such fluidity and potential is often evaporated during the production of more fixed or completed artefacts. In its most flexible condition, the sketchbook is analogous with the conceptual metaphor of Gilles Deleuze and Felix Guattari’s “rhizome” (Deleuze and Guattari, 1988), in that it seeks to form connections and extensions in ways that differ from more orthodox patterns of design development. Rhizomic plants bifurcate for Deleuze and Guattari, growing their
roots in a fundamentally different manner to that of other plants, yielding shoots and grasses in unexpected locations. Their root networks split and divide, producing alternative and unexpected pathways through the darkness of the earth where normative boundaries and restrictions become irrelevant. The unknown and unplanned nature of this activity mirrors divergent thought patterns commonly found in sketchbook praxis.

Following Deleuze and Guattari’s allegorical analysis of the rhizome and the tree [where the rhizomic plant offers limitless and often surprising outcomes whilst the tree remains fixed and rooted] it is possible to form analogies within the production of architectural images. For Deleuze and Guattari, by way of comparison to the rhizome, the tree remains fixed in structure, its potential limited to the restrictions of trunk, branch, twig, and leaf, “where everything branches out from a central trunk – the little twigs branch out from larger ones, and so on, back to the central core.” (Deleuze, 1994). In a likewise fashion, the same metaphor helps to illuminate the essential difference between the unscripted nature of the sketchbook and the scripted nature of a computer generated image. One is fluid, the other fixed. Whilst the sketch is unfinished, unscripted, and open to change and mutation; the digital image is complete, scripted, closed to change, and therefore resistant to further evolution. One representation is in a state of becoming, whilst the other is a fait accompli. For Deleuze and Guattari, such a condition is endemic throughout the entirety of Western thought and culture, stating

“...we’re tired of trees. We should stop believing in trees, roots, and radicles. They’ve made us suffer too much. All of arborescent culture is founded on them, from biology to linguistics. Nothing is beautiful or loving or political aside from underground stems and aerial roots, adventitious growths and rhizomes.” (Deleuze and Guattari, 1988).

Although such a comparison is an intellectual leap (for Deleuze and Guattari have much more on their minds than the trauma of the disappearing sketchbook) the preceding analogy serves to illuminate an important point here; the freedoms offered up by a simple sketch have no place in a polished computer generated image. Moreover, a computer-generated image solution is an end itself, its inherent graphical projection and representational presence being its primary goal. A sketch, buried away in a sketchbook, is an idea in becoming, a vehicle for imaginative manipulation. Moreover, it becomes apparent that a sketchbook nurtures rhizomic modes of design related thinking and action. In its raw form, a sketchbook is not immediately predisposed to becoming an arborescent root and branch configuration, but rather, its inherent potentiality suggests the formation of the opposite kind of engagement, an approach more akin to that of the rhizome. Whilst there might be a passing resemblance to a homogenised structure whereby each idea is a further expression of the same exploration, these are passing moments in a far more expansive and interrelated network of ideas, observations, thoughts, statements, appointments, ‘to do’ reminders and even shopping lists (Deleuze and Guattari, 1988). Rather than merely being a controlled catalogue of past or old works, the design sketchbook is a dynamic network that allows for the free flowing of theoretical and imaginative applications enfolded within a process of incubation.

The creation of a designed artefact, irrespective of the discipline within which it is executed, is defined by the methodological constraints imposed upon it by the means of production. This is particularly true in the case of designed images and the realisation of complex artefacts, buildings, and machines. Commercial designers and architects, by
the nature of their practice, have to conform to all manners of commercial influences and compromises that are normal to the production of designed items. The complexities and rigour of commercial production inevitably define and shape any initial design vision as the needs of users, clients, budgets, and the modes of production always manipulate the final iteration of the designer’s primary conception. In effect, the nature of production leads to the formation of pre-determined habits of practice; ones that are worthy, reliable modes of production and as such can endure the rigours of the commercial environment.

The practice of keeping a sketchbook, however, engages the individual designer in a soupier, far messier affair than the systemic logistics of commercial production. They allow free thinking, sporadic and untimely propositions beyond the rigidity of the design ‘for client’ process. The contents of a sketchbook have a propensity for meandering, coupled with an inherent appetite for finding lines of flight steering away from fixed modes of thinking and doing. Engagement with the sketchbooks propensity for negotiating other, less rigid and confined avenues of thought, encourages its user in the development of unconventional modes of operation and eccentric forms of expression. The sketchbook offers up immediacy in its latent potentialities, it is ‘too hand’ and primed for action in ways that digital devices and software only offer limitations.

4.

Standardized architectural graphics associated with orthographic and perspective drawing have evolved since the Renaissance; however, their principles remain intact and applicable to image making processes synonymous with contemporary architectural practice and the academic studio. Despite an overwhelming discourse that prioritizes the architectural image over that of the lived experience of a building; architectural designers and educators alike still persist in their efforts to endorse a sense of fit between the traditional perspective drawing and the production of digital visualization. Whereas, as this paper proposes, there are absolutely core and fundamental problems with perceiving the digital image as being the same animal of representation to that of the hand drawn visual. Moreover, we would argue, the digital image is the absolute antithesis of the creative process as experienced in the keeping of a sketchbook.

The contemporary architecture studio – whether educational or practice based – is littered with the paraphernalia associated with the production of digital visualizations. Today, such spaces are rarely furnished with rows of drawing boards and drafting stools, rather they are superseded by the disembodied computer screen, giving the impression of being more call centre than design studio. Moreover, the contemporary perception of architectural design practice is that it is chiefly concerned with the production of images (virtual simulations of final built forms) rather than the production of representations that require interpretation by the client, and further translation on behalf of the designer, in order to be fully realized as buildings (Temple, 2007).

Frascari famously highlights these issues in his concerns regarding architectural image making and the legitimacy such lends to the construction the built artefact. Historically, the drawn image of a proposed building has featured degrees of separation with its built derivative, leaving scope for imaginative interplay to occur between its visual representations, the designer, the client, and the final iteration of the drawn as a physical artefact. Moreover, Frascari argues that the utilisation of architectural image making as a vehicle of the architects authority and legitimacy concerning precise similarity between the virtual architectural artefact and its actual built form has driven an impenetrable divide between architectural documents and their authors. In addition, he argues that
“A drafters contract based on this process of legitimisation obliges the architects to produce drawings that should not nurture any imagination. The outcome is that the reading of drawings has become an unimaginative routine; what was once a pleasant walk in the intangible vagueness of the realm of discernment and construing of factures is now a sterile exercise of the realm of contingency.” (Frascari, 2011).

This increasingly popular perception of the architectural designer as being primarily an image-maker in the production of buildings is not restricted exclusively to those outside of the immediate discursive field of the architectural profession. Designer as image-maker, rather than maker or builder, is gaining acceptance, or increasing levels of acquiescence, with architects and architectural academics alike. By endorsing the production of such images, architectural designers and educators often unwittingly contribute to the prioritization of the scripted digital visualization over the incomplete, unscripted, sketch-based representation. However, such is the ubiquitous nature of digital technology, that by seeking a compromise between traditional modes of representation and the digital visualization of architecture (or, conversely, by denying it altogether as a valued form of architectural representation) characterises much of the discourse concerned with the production of digital images within architectural design practice and education.

In effect, the representation of a building design through a measured perspective has always operated as a simulation of reality, as all optical media functions in a similar vein, producing comparable ocular tricks and effects in the way that they emulate the human experience of sight, depth and spatiality. However, the drawn perspective, by merit of its unfinished status, exercises considerable restraint in its efforts to become a full virtual simulation of any future actualization in built form. The same cannot be afforded to the advanced optics of 3D software and graphics programs, where the hyper-real simulation of the actual leaves no room for interpretation or imagination. In many respects, such simulations become objects of desire in themselves, a folly of the perspective representation, giving rise to a fantasy of the actual building that, once the actual building is experienced, leads to a sense of disappointment in the actual. The real becomes rather a let down when compared to the promises enshrined in its virtual simulation.

Frascari (2011) highlights these concerns also, attacking the pseudo legitimacy afforded to photorealistic representation (whether mechanical or digital) as generating a “…trivially unimaginative and visually impaired view of the constructed world” and he goes on to align such representations of architecture as being “…equivalent to those dreadful children’s colouring books…” that “…brings about a feeling of having imagined an image, when it is has been merely a following of guidelines. With use of drafting machines [electronic or non electronic], imagination is useless, only neatness is required” (Frascari 2011).

Julia Wood, professor of communication studies, describes communication as the systemic process through which individuals interact with symbols to create meaning (Muehlhoff, 2010). Having established that this paper is contextualized by, and concerned with, issues surrounding discourses in relation to architectural representation, it can be inferred that visual communication within the field of architecture is culturally generated through the practices and production of discipline specific artefacts such as architectural graphics. Stuart Hall anchors communication and meaning within the visual domain by stating that:

“Culture, it is argued, is not so much a set of things... as a process, a set of practices. Primarily, culture is concerned with the production of meanings, the ‘giving and
Arguably, this is the process by which representation functions through the exchange of buildable information between the producer-sender and the receiver charged with interpreting meaning from the artefact through a system of signification. Digital visualization, however, imparts non-decodable information from itself to receiver in a swift one-way transaction eliminating the opportunity for two-way exchange. The scripted nature of the digital image, and its inherent propensity for communication the completed artefact, negates the opportunity for exploration. Indeed, the closer the digital visualization becomes to a ‘photorealistic’ image of the building as will be, the less likely the opportunity for change, evolution, and development can be realized. For such to happen, the digital image has to unpicked, demanding a reverse motion through the design process. The sketchbook, by comparison, encourages the exploration and evolution of a building towards its presentation as a proposal rather than finished artefact. Whilst sketchbooks and the act of sketching offers up freedom of creative endeavour, the digital image overwhelms such opportunities, evoking a tyranny of scripted control over creative exploration, it dictates the completion of the design journey. The journey effectively ends before the first steps are taken.

There are, of course, many stages of the design process that lie in between to the diametrically opposed architectural representations of sketch and digital visual and, moreover, stages that capitalize on the various merits common to both representational methodologies. Designers may well print out digital images, trace over them by hand, then transfer their attentions to further sketchbook-based exploration. This mixed approach to the production of architectural representation goes someway into claiming back the fixed, scripted nature of the digital image; it redeems and reclaims the digital image, allowing it to become transient and open to change once more.

Frascari (2011) notably extols the use of the ‘hybrid’ image in the production of architectural drawings, making similar claims to the redemptive power of chimeric images forged from analogue and digital systems of representation. More significantly, he claims that the utilization of hybridised imagery (being that of collaged elements of sketching, found photographic material and digital produced photorealistic representations) reinvests the ontological into the architectural image. A quality he regards as having been lost “…because of the present instrumental understanding of drawings which is firmly rooted in the erroneous notion that photographic representations must be the only ones able to sanction plausibility.” (Frascari, 2011).

However, this redemption of the digital image through mixed praxis is not in question here. Rather, we are concerned with the exclusive representation of the built artefact through photorealistic digital representation. The use of hand drawn techniques within systems of digital manipulation inherently breathe life into the fixed tabula rasa of the photorealistic digital representation. Arguably, if the two approaches are mixed, the digital image is no longer digital in the true sense of the word, but rather more fully virtual and actual in the Deleuzian sense. The integration of sketching and the digital representation produces a digital chimera that becomes open to change and interpretation via the action of osmosis through a scanner; in effect at least, the digital image becomes healthily polluted by an ontological infection afford by the sketch.

Baudrillard considers the loss of meaning through the proliferation of information and the simultaneous reduction of communication claiming that artefacts, specifically images,
no longer possess signification and therefore make reference only to other images in a conflicting relationship between production, artefact, and meaning or reality (1972; 1981; 1987; 2004).

Freedom of design communication and its increasing reliance on digital technologies are the paradox of postmodern culture. Devices and applications associated with contemporary architectural digital imaging are designed and manufactured to integrate and increase communication but, in fact, lead to isolation, segregation, and detachment from the process of architectural production and realization. Baudrillard maintains that communication technologies are designed to “fabricate non-communication.” The very disciplines designed to illuminate the role of media technologies in the act of improving or facilitating better communication have merely aided the proliferation of a more closed, one way conversation concerning the evolution of the architectural artefact. (Smith, 2010).

From Baudrillard’s point of view, the image is not solely bound to the hyper-real representation. That is to say, the hyper-real architectural image, or more specifically the digital visualization, does not and cannot represent reality or the real. Not only is the visualization autonomous, it also displays the characteristic inability to communicate and connect conceptual references. With indiscriminate use, the digitally mediated, scripted and complete visualization is often reduced to its iconic properties. This is not the case with the representation that is produced within a system of signification, that being synonymous with the architectural sketch, the unfinished and unscripted idea that is in a state of becoming. The visualization, however, is grounded in redundant self-referential formalism of the scripted image (Perez-Gomez and Pelletier, 1997). The digital visualization may be prolific as a result of the function of its mode of production; nonetheless, it is simultaneously hermetic and self-indulgent. It bombards the viewer with information yet communicates nothing. Technologies available in the digital studio are keen to serve as the catalyst of the phenomena, fast-tracking the trend without pause to consider the long-term effects on the profession, designer, student, or indeed, the contemporary built environment.

The purpose of this paper has been to extol the sketchbook and the process of sketching as (still) being a central activity in the evolution and communication of built artefacts amid the significant effect and impact of digital technologies on the same. Moreover, the paper argues that the architectural sketchbook opens up infinite virtual possibilities that are lost, ironically, when virtual digital technologies are the sole agency in the designing of built artefacts.

Perhaps it is of greatest importance to consider the status of communication of architectural information. If it is not, visual communication is bound to continue along the procession of simulacra towards a pre-scripted hyper-reality, at which point, the discipline of architecture itself will need to be re-evaluated.

REFERENCES


Benjamin, W. 2008. ‘The work of Art in the Age of its Technological Reproducibility’ in Underwood, J. E.


Muehlhoff, Dr. Tim. 2010. [lecture on communication theory posted on youtube], [accessed 10 March 2011].


PROLOGUE

Relatively little is written and less taught, in general terms, about the processes that might be used when working on an architectural design problem. This paper summarises some attempts to address that through a presentation (first given in 2007) to 3rd year and a workshop given to 5th year architectural students, to encourage them to more consciously structure and elaborate their design process.

Design is generally seen as a process of framing the problem, or of drawing up a brief, followed by making a proposition or speculative proposal followed in turn by analysis and evaluation of that proposal. Proposition can be facilitated by looking at precedents or by the use of concept, metaphor or abstraction. Analysis and evaluation can similarly be facilitated by developing an idea of the whole project and its values, and using this framework to assess the steps taken.

Design is clearly an unpredictable and uncertain process and can involve undertaking a continuing process of trial and error. The next step cannot usually be deduced, or induced, from the previous one. It can sometimes be seen as an abductive process of “inference to the best explanation”. The American philosopher Charles Sanders Peirce (1868, 1878, 1883), though working in the field of the philosophy of knowledge generally rather than architecture, first introduced the term as “guessing”. What is inferred is framed by both intrinsic and extrinsic values.

Karl Popper (1959, 1963, 1972/79, 1994), through his theory of Critical Rationalism rejected inference generally as offering any positivist sense of truth and instead offered the notion of greatest value for the least likely proposition that cannot yet be falsified. The three steps he outlined were: problem situation, tentative theories and error elimination. This model, again conceived in relation to philosophy of knowledge generally, was adopted by Michael Brawne (1992, 1995, 2003) for his elucidation of the architectural design process as: project definition, trial solutions and design development. Alexander Wright (2011) developed Brawne’s version of the Popperian model as a Critical Method for design education and elaborated ways that trial solutions can be generated under the headings of typology, determinism and abstraction.

The text below is more idiosyncratic but complementary to Wright’s Critical Method and considers in particular the initial framing of the problem (The Brief and Your Goals) the designer’s method of working (Your Process) and offers some example exercises as alternative ways to generate trial solutions (Some Exercises).
ABOUT THE PROCESS OF DESIGN

“How will you go about finding that thing the nature of which is totally unknown to you?”
(Plato Meno ca 387 BCE trans. in Solnit 2005)

To me this quote encapsulates the essence of the creative design problem. It is what makes being a designer so exciting: facing the unknown. The creative act requires us to move into the unknown.

But that does not mean we cannot manage the task. We can develop the brief, make explicit goals, choose a working method and use design exercises. A design process is not homogeneous. There are many facets to each architectural problem. It is not possible to address all aspects at once, so consider a few at a time. For example, architecture is partly comprised of how it acts in space: thresholds and boundaries, shared or social spaces (their scale, shelter, privacy and connectedness), about a reading of space, about a journey, about how it is used. It also is about how it is experienced by our senses, which is much more than physiology. It is about the memories, ideas and cultural baggage we bring when responding to materials, textures, smells, colours, heat and cold, sounds and atmospheres. It extends to our awareness of craft, detail and aesthetic composition.

The design process is not usually linearly additive. When we look at the whole task in hand we can choose one particular problem as an intermediate target and work with it. On the way we will make discoveries and create possible solutions. Further along we can choose another aspect and set a new problem to work with. As we progress we will gain both a wider understanding of the issues and constraints involved and begin to see a range of possible threads or solutions to pursue and develop.

Many students avoid starting multiple strands as they are afraid of the perceived difficulty of reconciling them later. The job of clarifying and developing different ideas is usually more difficult than the task of integrating them. Once the ideas are made explicit it seems the subconscious can begin to process them and the pieces can more easily fall into place, cross-fertilize or be allowed to die away as being less appropriate.

So in summary the design process is made up of different types of activity; it can be enriched by setting oneself particular design exercises which also serve to create more manageable and less scary pieces of work that can, as a result, be more enjoyable. In many weak schemes it is clear the student started with an end product in mind and then worked backwards to fill in the gaps. Fear or a weak design process may both be contributing causes. It is surely more interesting and rewarding to work in a more open-ended way and to use the process of design as an exploration of possibilities and ideas. These notes are some of my suggestions for how to structure that exploration and develop one’s design process.

1. THE BRIEF

Consider different aspects of the design brief given to you and consider filling in gaps or amplifying what is given. These aspects might come under the following headings.

Aesthetics

Consider what the building should look like, what it might feel like, the visual and sensual culture of the object. Consider what qualities are appropriate rather than necessarily give definite answers. Examples are, aspect: open or closed; material choices: contextual or acontextual (i.e. like or not like its setting); form: orthogonal, collaged, extruded or organic; complexity: simple or developed; surface: true to material or patterned or coloured.
Sustainability
Consider ecology, technology, economic viability and the material choices that might be appropriate. Particular ecological concerns are: climate change (especially CO2 and methane emission, primarily from producing electricity and heat), pollution (especially persistent organic pollutants [POPs] from building materials like plasticised PVC, leaching via sewage and rivers into the sea, disrupting the reproduction of marine life), resource depletion and maintaining biodiversity (such as specifying timber certified by the Forest Stewardship Council from sustainably managed forests).

Social
Consider how the building will act, how it can be used and the possibilities for the empowerment, or otherwise, of its users including also the quality of public realm and how the building relates to or transforms public space. So much of our city space gives priority to vehicles over people to the detriment of the social life of the street; look at examples using shared space. Many specialised buildings have uses delimited by time. What other lives could the building have "out of hours".

2. YOUR GOALS
What do you want to achieve? Set some specific goals that come from your own agenda. These can come under the headings of aesthetics, sustainability and social or be framed in any way you choose.

Examples:

“I want to work with a more complex and responsive geometry. For the last three years I have always done boxes and I want try something different, to move away from that now” - Chris Brown.

Chris built an experimental series of models casting plaster into a cube filled with balloons. These became concept models for his hotel with vaulted womblike rooms.

“I don’t know what the material of my building is going to be but it I want it to relate to my chosen brief for an arts and craft sales gallery and workshop. I want it to be hand crafted and jewel like” - Siba Adom.

Siba’s façade became a series of iridescent jewel like panels. Siba now runs a jewellery and accessory business in Accra.

“What uses could a community centre have and how could I use the concept of weaving strands together to make one” - Louise Thompson.

Louise’s concept model showed weaving as a way of closing to form a roof or solid façade and unwoven strands as a way of making an open façade or gestural entrance.

“What would make good contemporary high density housing and how can I use the concept of a hedge between the city and the green belt to make it” - Isabella Percy.

Order and chaos struggle for a harmonious balance, to make a porous and habitable structure on the southern edge of Melkham.

3. YOUR PROCESS
How will you work? What is your way of managing your design process?
3.1 Choices
Design is all about making choices. That does not mean the design process has to be entirely rational. You can equally respond to instinctive suggestions but try to raise your awareness of where the impulses come from, what is behind them. Making these explicit can help you evaluate them.

3.2 Work
Work, especially drawing by hand, to your limit of that moment. Sit under a tree (or any other quiet space away from distractions) and draw by hand until you are ‘empty’; until you feel you have drawn out anything that is sitting unexplored in your mind. Once one thing is committed to paper it often allows other ideas to float to the surface. Sleep on it overnight and see what has changed, shifted, moved on, refocused, emerged the next day when you sit down to the same task again.

3.3 Medium
Change medium. Once you have exhausted one medium, for example hand-sketching, switch to another medium, such as modelling, and choose a material to work with: clay, plasticine, card, balsa, plaster. This will change what you can explore and what you can resolve. As Marshal McLuhan (1964) said “the medium is the message”. Each medium creates its own environment, which is favourable to some messages whilst being less responsive to others.

3.4 Inner Voice
The inner design voice can be very quiet and small. You need to consciously give weight to your inner voice, trust your judgement and, if you later think you have made a mistake, learn from it.

Often in tutorials a student will say “that’s what I meant” or “that’s what I thought” but hadn’t yet found the resolve to commit to that idea on their own. Take courage. Peter Smithson famously encouraged his students to try things and added that for him many of the things he tried did not work out.

3.5 Dialogue
Work through dialogue with another. It is not essential but it will make things easier. It is much harder to get stuck this way.

“Long conversations
Beside blooming irises
Joys of life on the road”  Haiku by Matsuo Basho

4. SOME EXERCISES (TO GENERATE TRIAL SOLUTIONS)
Develop your design process by creating specific studies or mini design tasks. Think of them as being like ‘five finger exercises’ for the piano. They can be a way to get started when it is not clear to you where to start from. The blank white page can be an inhibitor to creative thinking. It is also important to allow yourself to explore options speculatively without thinking you are committed to them. You can change your mind. Going somewhere you later judge to be wrong and looking back can tell you about what you consider appropriate.

Exercise 1: Favourite Object
Pick a favourite object, for example one you carry with you, or choose a significant found object.
Consider why it is a favourite or significant object, its qualities. How might your building do something similar?
A butterfly knife that combines opposites: hard, functional, threatening but also ornate, filigree, pretty; also: what is concealed and what is revealed. Georgina Weston.

From the latter theme Georgina went on to create a group of houses, each partly buried and partly cantilevered from the sloping site, emphasising respectively privacy and display, the introvert and the extrovert.

A mobile phone: black, smooth, rectilinear, the size and shape of its components like a fractal with the parts a smaller copy of the whole and vice versa. Ellie Redmill.

This lead to a modular building where the form of each part related to the whole while also dramatizing natural light through exchangeable elements in black and white.

A twig: how it joins, the form at joints and changes in direction. Julia Wildfeuer.

Julia’s design for a very small building ended up with partitions inflected by the presence of their junctions with other walls, in a way that revealed their presence, somewhat in the manner of soap bubble models or the plans of Hans Scharoun.

**Exercise 2: From Free to Orthogonal Space**

Part 1: sketch imagined spaces and relationships as freely and loosely as you can in a cloud or bubble like way. Draw again and again in this way, trying different starting points or relationships. Coalesce the parts into a more definite arrangement or pattern.

Part 2: from the emerging pattern and relationships develop rules or straight guiding lines and gradually coalesce or convert further into a more orthogonal form. Strive to distil, to edit down to the main moves only. How few moves or gestures do you need to achieve a plan that works?

The example drawn above is obviously a cheat as, to the best of my knowledge, Mies van der Rohe did not work this way. The amazing thing for me about the Barcelona Pavilion is its implied choreography. The well timed dance one is guided or led along by successive prompts: the stairs, shelter, the view of the hidden courtyard, the statue of Alba, the long view to the end and finally, when there is nowhere further to go, resting on the bench facing the water.
Exercise 3: Memory Scale Collage
This is a way of abstracting the design task as one of scale and grain.

Part 1: list relevant reference spaces or objects you know. Paste the plans over your site.

Part 2: from the reference objects determine the grain(s) or scale(s) relevant to your brief.

Abstract them as a grid that is spaced apart by the relevant distance(s). Draw in response to the emerging grain: things existing (kept) and proposed (new). Also look at what follows the grain, what transgresses (is larger or differently proportioned), what sits well below (more compact spaces, points or nodes). Theses scale exceptions can now be seen and manipulated in the foreground in contrast to what is typical or normal.

Rem Koolhaas and Elia Zenghelis (OMA) working on the competition for the Parc de la Villette, Paris in 1982 decided they needed to discover the scale of the park. Initially they pasted buildings and then squares over the park. Then, realising that a park is not a building and a square is more readily defined by its edge conditions, they decided to find a relevant social dimension. They decided that you could walk past a friend having a picnic without greeting them if you were 25 metres away and used this social scale to cut the park into 44 strips. Now they knew how big the park was.

Exercise 4: Wallpaper Map
Choose a range of ready-made patterns or wallpapers that you judge can relate to your concept. Sketch or list different ways of interpreting a chosen few of these patterns. For example: as solids and voids, as contours, as areas of different activity, as private or public space etc.

Phoebe Braidwood used this exercise (figure 4) to begin her design for a Cider Park on Weston Island, Bath in 2006, mapping and then modelling different strategies from found patterns.

Exercise 5: Name
Whatever idea or aspect of your project you want to explore: give it a name. Then diagram that name in as many ways as come to mind immediately. Once you have diagrammed all the possibilities that come easily to mind, choose another name and draw the diagram(s) for this new name.

Exercise 6: Muff on a Huff Puff
A game which is a sort of architectural version of ‘picture consequences’ which one Danish family I know calls ‘Muff on a Huff Puff’. It exploits the hive-mind to develop ideas. A list of players is drawn up with the accumulated creation going off on a journey round a circle of people. An alternate version has the pieces returning to you at each stage, so it is more like a dialogue without words.
Ideally each stage would take place on a subsequent day so one could sleep on it overnight. Each stage should be limited in drawing or modelling time to less than an hour, preferably 30 to 40 minutes. Aiming to be generous with thinking time, even if thinking takes place in the background, and economical with production time.

Pick a concept you wish to use in your building and draw an image or conceptual diagram. Give it a name of one or two words and pass it on. You receive an image or diagram with its
name and use this as a brief to draw or sketch an architectural idea or device that develops an aspect of the building and pass it on. You receive a drawing of an architectural idea or device and in response develop this into a hand drawn plan and section to scale and pass this on. You receive a plan and section drawn to scale and in response make a quick study model. You receive a model. Describe a construction detail of the modelled building in less than 50 words, like a detail brief, and pass this on. You receive a description of a detail and you make a sketch drawing, to a scale, of this detail and pass it on. Pin up the results one above the other. Thus each column starts with a conceptual image at the top and ends with its related construction detail. There can be a significant element of Chinese whispers with some unexpected interpretations along the way, but also some serendipity (happy accidents) or enlightening proposals.

EPILOGUE

The notes above deal primarily with the first two stages of the design process: project definition and trial solutions. Critical analysis and evaluation have not been discussed. I am aware that though some students find generating trial solutions difficult there are others who generate abundant material but seem to find bringing this to a conclusion challenging. They need to develop a corresponding level of critical or analytic ability. Often this will come with greater experience. Sometimes it is just a matter of developing their confidence in their own abilities.

Consider also that not everything has to be designed. In developing the brief for an ideal school, for an internal design challenge at Feilden Clegg Bradley Studios, I interviewed people about their memories of their own time at school. The most potent places were not the programmatic spaces, classrooms or halls, but the left-over spaces, the less defined spaces, adopted or adapted by them, alone or as a group, for their own purposes. So in our brief we called for the inclusion of ‘Ambiguous Space’, space to play or dream in. We are creative and curious apes. We engage with our environment in diverse ways. Try to capture the spirit of what is possible.

REFERENCES


Popper, K. 1963. Conjectures and Refutations: The Growth of Scientific Knowledge,


Popper, K. 1994. All Life is Problem Solving


Education for uncertainty

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INTRODUCTION

At the time when the RIBA is rewriting its validation criteria and we are in the process of setting up a new school of architecture our focus is on the development of a new framework for architectural education that puts professionalism, collaboration, research, industry and employability first. Our curriculum has to have currency to deliver knowledge with relevance in the culture and context of making buildings today – subjects such as energy literacy, low energy design, from concept to post-occupancy and understanding the basic principles of sustainable design. It also needs to deliver critical research skills. The dialogue with practice needs to be fluid; we need to engage in dialogue, to understand the possibilities for us all to learn and engage with Architecture - the academic discipline and profession as it evolves in the 21st century. A school of architecture can situate between the academic and the pragmatic, the imagined and the real. The profession is an interdependent entity. A new education model needs to be inclusive, encourage participation from education and practice to create a platform for open and equal discussion and to learn from each other and respect different positions and perspectives. What is the difference between being a practitioner and an educator? When are we in designing mode, researching mode, learning mode or teaching mode? We are all part of a system whether we are students, architects in practice, architects in education, researchers or interested participants in the discipline. We are all contributors to the evolution of our field. Our interest is not in delivering a “fantasised and idealised notion of architectural practice” (Sarfatti Larson, 1993, p. 10), instead we want to help students develop the skills, knowledge and ethical compass to make what they will of its constantly shifting potential.

“Perhaps the most important thing that we can teach students is how to respond to uncertainty and change, how to themselves become resilient” (Nowotny, 2015, p. vii). The focus of this paper is on developing a professional architectural education for uncertainty which embraces “the beautiful risk of education” (Biesta, 2014). We look back to 1960s when “Interdependence and Uncertainty (Tavistock Institute, 1966) was firmly on the agenda and architecture and the social sciences achieved a marriage of convenience that dwindled to almost nothing with the demolition of public sector ‘salaried architects’ in the UK (Morris and Mogey, 1965). Both architecture and the social sciences have, however, moved on since this time and we argue that the time is ripe for new, more nuanced interdisciplinary work drawing on the subtleties of new methodologies and methods.

We begin with an examination of one key precedent for such an education, before moving on to a discussion of the skills, knowledge needed for the exercising of professional judgement and the learning environment we think
necessary to become resilient professionals sharing risk in a responsible and critical way with society. If risk is suppressed in one place it inevitably emerges somewhere else, hence a profound need for professional and ethical judgment. We argue that education for uncertainty is also education for diversity as it has much to do with sharing contextualizing knowledge while acknowledging and bringing forth inequalities of risk.

1. AN EXPERIMENT IN PROFESSIONAL EDUCATION FOR UNCERTAINTY

The architecture profession in its official guise began in the early nineteenth century as a reaction to the inadequacies of the pupillage system (Mace, 1986, p. xvii). “The history of architectural education in Britain can therefore be seen as a search for an alternative to pupillage motivated by a negative perception rather than a clear ideal of something better” (Powers, 2015). In the 1970s it was recognized that, “lacking a research tradition of its own” architecture had an over reliance on traditions from other disciplines (Broadbent et al., 1970) and further, that “the design, or action disciplines tend to remain intellectually weak” and “subject to every wind that blows in the academic world” (Hillier and Leaman, 1976). As professional schools were assimilated within universities they lost “commitment to applied work” even though they were set up to link practice with research (Boyer, 1997). Remedial action was, and still is needed.

An early example of “education for change” is provided by the first paper in the short-lived journal Architectural Research and Education, founded in 1970. “Diploma Project 1968-69”, its generic name designed to suggest the open nature of its brief, is an account of a studio designed to promote “professional effectiveness”; “to encourage education for change”; “to improve skills in advanced architectural design”; “to develop effective attitudes to the professional role and to prepare for team work in professional practice” (Abercrombie et al., 1970). The evaluation of the project, a published pedagogical research piece was structured under these headings. Its first author – the 31 students and staff were the project team - was Minnie Louise Johnson Abercrombie, then leader of the Architectural Education Research Unit (AERU) at the Bartlett; a psychologist by training. Their concern, ‘education for uncertainty’, is our concern, leading us to speculate on the best way to translate this into a 21st century context.

The project, based on a series of earlier experiments, offered a carefully choreographed educational experience lasting an entire year. It is worth noting, since we are now at a time when UK education is in danger of bifurcating between research and teaching (BIS, 2015), that it was partially funded by the Leverhulme Trust and the Social Research Council. The project shows the influence of Richard Llewelyn-Davies who was Professor at the Bartlett from 1960-1969. Llewelyn-Davies was a key figure in the development of the 1958 Oxford Conference and instrumental in mapping out a research vision for the RIBA at that time (Llewelyn-Davies and Cowan, 1964). The “intention” of the project was to give students responsibility for their evolving education “by involving them in planning the course, choosing their design projects and assessing their work” (Abercrombie et al., 1970). The studio teachers were “participants” in this collective process. The “core activity” of the unit was conceived as a sequence of design projects of increasing complexity. Following a short introductory exercise, designed as an ice breaker, that would raise a series of issues about the “current professional scene”, the group was given a “closed” task, an architectural competition for 24 flats for old people in Byfleet, Surrey which led into broader discussions about “social and ethical” problems of design for ageing. Moving on to the next problem North Kensington, then a “twilight” area of London, was chosen as a site as it meant that the students could work with a variety of agencies interested in its development. This area became the locus for an exploration of issues of “social and architectural concern”
individually and in groups in the period between Christmas and Easter. The last term, from Easter to the summer break, was then devoted to a synthesis of studies by the whole class, which took the form of an “integrated proposal within the specified urban area”. This process was accompanied by introduction to a variety of current case studies intended as “a vehicle for understanding the application of technology, economics, contract procedure etc. to design”. “Free group discussions” based on a lecture or readings happened on a weekly basis, often straying from their intended course.

Evaluation of the project was based on staff observations, student log books and comments made in the “free group discussions”. A 1964 paper by Newton Watson shows that the Bartlett had been pioneering new forms of assessment for some time. Having dispensed with the ‘jury’, Watson and his team wanted to recast end of session assessment as “a teaching medium”. It was to take the form of a “discussion” accompanied by a “studio work record”, explicitly not an assessment, with comments under the headings: “communication”; “analysis of the problem”; “structure”; “materials”; “functional planning”; “services” and “inventiveness” (Watson, 1964).

The results of the AERU unit were perceived as patchy – but the team are to be commended for their degree of self-critique and willingness to admit to failure, enabling us to then learn from their mistakes. As is so often the case today, staff reported that students often experienced difficulties in making design proposals after doing extensive amounts of “social” background research (Abercrombie et al., 1970) accompanied by “frustration” and a loss of “confidence”. The students, apart from one exceptional group, started working from home, failed to attend reviews, became more and more siloed and generally there was “a great reluctance to work as a community on mutual assessment”. The highly engaged group however devised an engaging, choreographed celebration of their project:

“. . .one member of this group contributed proposals for a mews housing scheme, the spatial organization of which fulfilled his wishes for “participant democracy”, by which the occupants could choose their own combination of spaces. Another member concentrated almost exclusively in provoking radical political ideas in the audience. The excessive length of the presentation [four hours with a short interval] inhibited immediate feedback, but the demonstration of skill, energy and enthusiasm made an impact which has subsequently been favourably commented on.”

In general, “the designs were not remarkable for their originality”. Some students reported “a newly acquired confidence as self-learners and critical thinkers whilst others lamented their “turmoil, distress and uncertainty”. Abercrombie et al do not report on whether they found that this turmoil presaged intellectual breakthrough or despondence, but clearly this is an uncomfortable and delicate moment in the educational process if students are to become self reliant. It also has a poor fit to our current climate in which the student is a “customer” and league tables of student satisfaction are paramount.

Clearly the overall culture of the school and the university is one which had already acclimatized Bartlett students to a rigid structure, with success measured in the attainment of good grades.

Nowadays we are very familiar, certainly at MArch level, with offering an open brief in which students choose both site and purpose – this does not seem to have been the problem for the AERU project. Reading between the lines it seems that the main issue
was the self organization, self-assessment and team-working for which the students, who came from a diverse range of educational backgrounds, were deeply unprepared. At the heart of this was their difficulty with justifying informed professional judgments both individually and collaboratively to guide their actions going forward. Despite their desire to provide a loose and challenging framework that would allow students to innovate in safe circumstances, the team were hindered by both their framework for assessment and the need to fulfil professional validation criteria, a problem that AERU tried to address by appointing a team of external examiners who reviewed the students work on an ongoing basis. Significantly they reviewed the process not the product (Abercrombie et al., 1970).

The RIBA criteria, currently up for review, have changed very little over the last fifty years. Now with the RIBA Review of Education we have a real chance to make them better. The advent of digital technology makes the development of an ongoing reflective portfolio in which students choose and chart their own way through their learning an easy option, in a climate in which architecture has become so complex that they cannot learn everything. The concept of the “reflective practitioner” as developed by Donald Schon is an important set of attitudes and learning approaches to develop in architecture students, as something that will stay with them throughout their professional career (Schon, 1984).

In trying to create an education that embraced uncertainty, the AERU team were taking a great risk, the important thing being the sharing of that risk with the students. “Classrooms that embody education as a practice of freedom cannot be made entirely safe. These learning environments are unavoidably risky in terms of the intellectual regions they engage, the emotional experiences they engender, the verbal exchanges they facilitate, and the actions they endorse” (Glass, 2004).

Whether students want or are ready to accept that risk is another matter, particularly since risk is highly culturally specific (Hood et al., 2001).

2. PROFESSIONALISM

David McClean notes that a central problem of architectural education as it is framed at the moment, is that it makes students dependent on their institutions and on their teachers. These dependencies on tutors are constructed or reinforced by a lack of clarity of learning intention, confusion over the purpose and role of projects in relation to learning outcomes, the nature and quality of feedback, and in terms of what is assessed and valued. Diversity in learning style and intelligences exists within student cohorts. For a pedagogy to be inclusive, this diversity must be understood and explicitly accommodated in the learning process. Inclusivity is fundamental to engendering a sense of belonging in the student, as is the acknowledgement of their personal opinions, views, and experiences. The habituation of reference to others, of formation of judgments that assimilate personal opinion with external views, and information gleaned from multiple sources, is key to independent learning, this process cumulatively allowing the student to develop a sense of independence over time (McClean, 2009). The mode of engagement is arguably more important than content.

The paradigm shift away from teaching to learning identified by McClean has parallels in the evolving professionalism debate. The word ‘profession’ has etymological origins in the Latin word ‘profiteri’ which means to declare openly. To be a professional is to profess to having a level judgment above and beyond that commonly available in our population. For us the ability to make these judgments resides in research skills, the rigorous use of knowledge and the critical application of ethics (Kaye, 1960), categories that give
structure to this section. As knowledge has been democratized, the professions have come under attack (Eraut, 1994), in particular for a lack of ethical compass (McNeill, 2006). Nowotny suggests that experts need to make explicit the way in which they deal with uncertainty, in this way sharing an understanding of its nuances and responsibilities with society (Nowotny, 2015). In the case of architects this would mean admitting, discussing, sharing and learning from failure, involving society in the creation of a more solid body of knowledge on which to base decision making. It is the ethical duty of architects to put the interests of society, not individual clients, first (Green, 2011).

The amount of time needed to become a professional is debatable (Sarfatti Larson, 1977). Arguably, architectural education is too long (Pringle and Porter, 2015), yet at the same time you never stop learning to be an architect. Education is there to encourage good habits of life long learning and self development both in yourself and in others, not to impart a quickly dated body of knowledge. These attitudes and values around learning and professionalism start in the school of architecture.

Geoffrey Broadbent and his fellow editors at the Journal of Research and Education made a plea, again equally as relevant now as it was then:

“The RIBA must explicitly allow the schools to diversify their criteria of excellence for the award of degrees, so that students who specialize in understanding design problems can be regarded as equal in all respects to those who specialize in their solution. Both types are appearing in the schools; both will be needed as practice uses more information originating in research; above all, both will be needed if the growth of architectural research is to lead to a better environment. It goes without saying that it should be no more difficult for students who take this route to qualify a full members of the RIBA” (Broadbent et al., 1970).

Broadbent and his colleagues here recognize that some students might choose to examine the processes through which architecture comes into being rather than immerse themselves in that process to produce a finished product, the design or building. The profession needs people who both go through the process and those who examine that process. This is an extremely important point that many of us have hit upon more or less unconsciously in the process of teaching and which we will address explicitly through our curriculum.

A. SKILLS

“Within this context one of the central predicaments facing the education of today’s architects is that of defining the designer’s expertise in relation to an industry in revolution” (Sheil, 2015). The skills of architects are not widely understood or recognized, but we want to make them explicit so they can be shared by non-architects and architects in formation. The creation of new knowledge is described as having four phases: “socialization”, “externalization”, “combination” and “internalization” (Lu and Sexton, 2009; Nonaka and Takeuchi, 1995). Essentially, this a cyclical journey in which tacit knowledge is converted into new explicit knowledge and then back again at the levels of both individuals and groups. We are fully aware of architectural culture’s refusal to be pinned down or made explicit – but, we argue, there is a profound need to attempt to set out our stall if only to allow others to engage with it.

Although rarely recognised, the primary skill set of architects, we argue, is research. Research is “defined as a process of investigation leading to new insights effectively shared” (HEFCE, 2011). It is a globally respected language that cuts across cultural
divides. Much of what happens in practice involves investigation, but a major barrier to the advancement of the profession is dissemination (Samuel et al., 2013) – we rarely learn from our mistakes. Our vision of architectural education embodies a feedback loop of investigation, reflection, shared critique and improvement, a process not dissimilar to that undertaken by, in our view, enlightened practices that are fully engaged with building performance evaluation, not just in terms of energy but also in terms of social and cultural value.

Kyna Leski observes that the stages of creativity are essentially the same, irrespective of whether the creativity is artistic, scientific, technical or business (Leski, 2015). The first stage in a design project is “The collection and ordering of information”, which always “presupposes a theoretical framework of reference” (Echenique, 1970, p. 25). Architectural models, whether built in cardboard, portrayed on a wall at a studio review or parametric, are representations of “theories” if not methodologies (Echenique, 1970, p. 30) and it is time to make this explicit (Dye and Samuel, 2015).

Research and representation go hand in hand. Whilst writing might be the traditional tool of many researchers for the exploration of ideas, drawing, modelling, mapping, filming and designing are the tools of architects. We believe that “tools”, a word acceptable in architecture culture, are actually “research methods” by another name. In our first year students will be sent out to examine the city seen through a range of tools, which will, in later years develop into a “tool box” or “mixed methods approach”, hopefully connected through triangulation. These are key research skills and need to be seen as such as they are ripe with potential for interdisciplinary exploitation.

Our curriculum will build on the definition of “Architect Types and Skillsets” developed through extensive consultation by the Arts and Humanities Research Council-funded ‘Cultural Value of Architecture’ project (Samuel et al., 2014). The project set out three overlapping typologies of architectural practice, each working with a different value system: cultural value, social value and commercial value. The different architects working in each of these value systems apply very different research methodologies to what they do. The social architect, concerned with creating social value is very often engaged in participatory methods. The commercial architect, concerned with maximising financial gain, is likely to prioritise economic methods. This taxonomy of knowledge economies within the field of architecture provides a structure for research training, tested and refined with a large group of practitioners, students and the public. We recognise the dangers of being reductive, exclusive and over rigid when trying to trying to be transparent, inclusive and explicit. The only way through this is through constant renegotiation.

B. KNOWLEDGE

“Somehow we have to produce embedded knowledge: i.e. insights that are there for excavating later, when the context is right but not until then” (Strathern, 2000, p. 189). If students are effective researchers they have the ability to acquire knowledge as necessary, however there is a basic level of subject-specific knowledge important for the practice of architecture. We have subdivided this into three categories: knowledge for making – focussing on product and traditionally the priority of many architectural schools; knowledge for collaboration, and lastly practice economics. Different schools place emphasis on different types of knowledge, for our school as much emphasis will be placed on collaboration and business as on the processes of design.

“Schools have infected a generation with an anti-business mindset”. (Pringle and Porter,
Students usually address practice at the very end of their training. In our case critical reflection on business will start at the very beginning. Practice economics encompasses a knowledge of existing and past practice procedure and the economies of the profession, monetary and non-monetary. The aim here would be to arm students with the economic and critical savvy to fight the cause of their field, something that is notably lacking in current cohorts (Imrie and Street, 2011).

Knowledge for collaboration includes digital tools for knowledge sharing such as BIM, manufacturing, the structure and methods of the construction industry, the wider knowledge economy and policy, including intellectual property. It focuses on supply chains, the meaning of globalisation and its impact on our environment and on ways for architects to become active in engaging with these debates. A key element of professional knowledge are regulatory frameworks which traditionally take a back seat in architectural education as they are thought to limit creativity. However, they should instead “be understood not as external to creative processes and practices, but as integral to them” (Imrie and Street, 2011). Codes and laws originate from a desire to promote public wellbeing and reduce risk within civil society. Participation in debate on the creation of codes is simultaneously a rarely acknowledged form of co-design and an expression of the professions contingency (Imrie and Street, 2011).

Knowledge for making of course includes tectonics – making with thought, inclusive design and space planning and place making. These will be taught and described as much as possible as explicit skills, not just as a vague subset of what happens in studio. Comfort, light, acoustics and energy, must of course be addressed, but in an intelligent way that addresses the complexities of human behaviour. More work needs to be done into the vital task of setting out the fundamentals of architecture in order to open it out to non-architects. Pedagogues such as Lorraine Farrelly and Simon Unwin who have set out to try to describe the basic elements of the discipline are not just producing text books, they are trying to give order to a field in desperate need of clarity (Farrelly, 2007; Unwin, 2014).

A further aspect of training students for an uncertain future is transferable skills. Schools need to promote a professional discourse that creates a balance between subject specific skills and more transferable professional skills in the explicit understanding that some students will stay in the profession and some will make the positive decision to go. The idea that “the major part of your education is always going to be the design of buildings” (Marjanovic, 2003) is severely dated. Students are well known for their dissatisfaction with programmes of architecture and whilst it may be the noisy and jobless minority who complain, it is unacceptable that any students should remain unemployed after such a long and expensive training (RIBA, 2015). Rather than giving sighing acceptance to RIBA statistics that only one in fifteen students who begin their studies at a UK school actually qualify as architects we should be making sure that there are more jobs for them within architecture if they want them by raising the impact of the field as a whole. If they do choose to leave the field it must be recognized that they are not “drop outs” but actually perform a very useful function in disseminating the use of architectural skills in the wider world (Sheil, 2015). We have an ethical duty to furnish students with the best possible chances of success in their own terms. The expectation of high workload, unsociable working hours and unreasonable work expectations start in the school of architecture and fuels the inward looking nature of the field.

C. ETHICS

To behave ethically is to acknowledge the rights and experience of others perhaps less
powerful than oneself, it is also a key element of being a ‘professional’, in other words weighing up risk. Criticism of architects’ ethics thus touches on a sensitive issue for a profession that is always looking nervously at its historically accumulated privileges. (McNeill, 2006b). Miles observes “architecture is an agent of the consumer society: it appears to act on that society’s behalf in reinforcing the orthodoxy of the market” (Miles, 2010). Judith Blau notes a bifurcation in the intention of architects who on the one hand are committed to doing good in the world and on the other, to following business (Blau, 1987). We believe in the possibility of practices combining business with ethics by accessing new research-related funding streams and by widening the menu of services that they offer to clients. An example in the UK is Architype architects who have been recipients of UK research council funding to assist their ongoing commitment to building performance evaluation and soft landings, helping users to use their buildings well, which in turn gives them a market edge in their field.

Students will be encouraged to take a holistic and critical stance to the subject and to recognise very often that practice is about the strategic movement of risk based on research. The global space within which architects operate often defy “regulatory frameworks of nation state” and inhabit an obscure world of global ethics (McNeill, 2005), one which can only be navigated by those who know how to access knowledge with ethical sensitivity. There are also important aspects of professional and social responsibility that schools of architecture have a responsibility to encourage within the student body. Our students need to understand and participate in the social issues in and around architecture. We want them to be actively involved as citizens in the debate around key issues such as: housing, public space and social concerns around environment energy use and accessibility.

In schools of architecture across the UK, ethics approval is increasingly a compulsory aspect of any project involving research though coverage is patchy. They are frequently allied to risk assessments, originally set up to protect workers and therefore key to responsible working. At the University of Reading, students must fill in an ethics application whether they will be working with people or not. A light touch version of which will extend to all studio projects, not as a paper exercise but as a fundamental acknowledgment of duty to others. Given that professional institutions such as the Institute of Civil Engineers have put in place an ethics tool to guide their members through this area, sensitive both morally and legally (ICE, 2015), it can only be a matter of time before architects too follow suit.

3. LEARNING ENVIRONMENT

Context is increasingly recognised as central to learning (Elton and Johnston, 2002). “Real learning takes place between students and out in the world” (Powers, 2015), hence the profound need for any architecture school to be permeable, to practice, to the wider university, to the wider built environment industry and to society. Building on the endeavours of Reading 2050 we want to create a school of architecture as an “Urban Room”, as referred to in the Farrell report as a vital accessible space for debate and discussion around architecture and the public realm. Simultaneously a research laboratory on the role of architects in the co-creation of places, and a place for students to experiment in engagement with civil society.

The Urban Room will focus on collaborative processes and strategic planning, rather than built outcomes, the domain of many of the project offices that are based in several UK schools. Such project offices have traditionally been linked to the development of Live Projects in their particular schools, sometimes because of the complex issues of professional indemnity. They take different forms and can offer academics and students
opportunities to be involved in real or Live Projects working with a real client on a real problem. This approach to architectural education is another example of simulating real practice problems in the student learning experience. Whether such offices, sometimes fuelled with ‘free’ manpower from students, have a competitive advantage over local self-funded practices is a moot point.

We seek to make Live Projects in synergy with practices, building on a model currently in development in the MArch at Northumbria University, in which students add value by bringing additional research capability to a practice project and its processes. “Live projects are, if pedagogically understood and appropriately managed, a natural setting for a situated, critical and inclusive education” (Morrow and Brown, 2012). They require brave tutors who can support students through uncertainty and the considerable demands of real clients in real situations. Live projects can be assessed, as they are at Sheffield University, by the client, by the students and by the tutors; each form of assessment brings into relief the different value systems at work, a critical understanding of which is vital to operation as a professional (Butterworth and Care, 2014).

The students in the AERU experiment took responsibility for a portion of their own self-assessment. It must be possible to develop a self-audit system that ensures that all students take responsibility for picking up the necessary skills along the way. Currently students fill in a PEDR log of their developing experiences. A new form of validation is needed that allows for the custom-build of learning in each individual student potentially through the use of digital mapping and which makes the full range of architectural expertise clear as a road map of potential.

It is widely acknowledged that architecture students must learn to work collaboratively with one another, just as the industry itself needs to become more permeable. Parnell notes; “the development of empathy and cooperation among students of architecture is identified as most lacking in the traditional model of their education” (Parnell, 2003). Wherever possible students will work collaboratively and we will work on current best practice to develop appropriate assessment tools (Butterworth, 2014). Tutorials in small groups are nearly always better, they encourage the development of critical skills, collaboration, shared responsibility and shared learning. They also protect the student from the one to one contact which can for some people and some cultures be very uncomfortable.

“One of the mistaken arguments for the retention of the crit is that it prepares for the real world – but at what cost? Answer: the development of alien vocabularies [spoken and drawn] understood only by architects, arrogance [attack being seen as the best form of defense in a crit], are the common traits, among others, which are established in schools of architecture and which then contribute to the formation of the character of the architect.” (Till, 2009) We argue that crits are based on a very outdated vision of the ‘real world’ – aggressive confrontation is no longer seen as good management and serves to perpetuate excluding and destructive leadership models - and should be reframed, in the manner of Nowotny, as collaborative research. The format of the review should be established and actively engaged with, by the students as part of their training in co-production and in the facilitation of events, a very key aspect of the architect’s role.

As the Bartlett exercise showed, university structures have traditionally worked against experimental pedagogists, but things are rapidly changing as innovation incubators are starting up across the world. The ‘Sliperiet’ at Umeå University in Sweden is a beautiful example. Combining “maker spaces and labs” with “work space for the creative industries”
it offers a common platform for researchers, students, businesses and public stakeholders (http://www.sliperiet.umu.se/en).

Researchers in the Sliperiet have recently been successful in bidding for major funding to develop a digitally printed timber house. Such an enterprise starts to model the real potential of academic/industry connection to which we aspire.

Working as an individual on the studio project encourages individualistic and unrealistic expectations of life in practice. The building as a project is a collective endeavour, it brings together a range of contributors in a team, from the design team, engineers, surveyors, to the client project managers, and the contractor. Collaboration between architects and the public is important and needs to be part of an education model, but collaboration between the built environment disciplines is also vital. This was an important observation of the recent Farrell Review of Architecture and the Built Environment (Farrell, 2014) and it is an ambition of the new school of architecture at the University of Reading, that the courses will connect to the built environment disciplines to create shared curricula around design and aspects of building implementation.

Education systems in Universities can be very deterministic and create barriers to develop truly integrative and collaborative approaches to learning, compounded through the logistics of budgetary planning. The idea of an education model that offers students possibilities of interdisciplinary learning connects to the idea that there can be instances in the academic context where we prepare students for their practice experience. A collective approach to the design project is one area that we can develop an understanding of team dynamics and participation.

As Abercrombie et al made clear, there is more to architectural education than working towards assessments. Rather than ‘over-teaching’ we want to provide targeted teaching that leaves time free for reflection and opportunities for students to develop into active citizens. Care will be taken with the student experience, developing their confidence to work with potential clients as well as real life skills around communication and team experience. Not all education experience needs to be assessed, nor should students expect it to be.

CONCLUSION

Our new school at the University of Reading is responding to a series of issues that relate to architecture as a profession that is intrinsically linked to the construction industry and economy. It is located alongside a School of Construction Management and Engineering, educating the Quantity Surveyors and Construction Managers of the future. If we are to start new cultures of problem solving, collaborative thinking and working in schools of architecture (Farrell, 2014; Morrell, 2015), we need new frameworks for teaching and a shared language of research. The new School can offer a place where research is at the centre of the student experience, not peripheral to it, and where practitioners can develop a dialogue with the school around their own research agendas and potentials.

Skills, knowledge and ethics, the fundamentals of professional judgment, then become a cohesive framework for the delivery of learning outcomes and self-assessment, rather than a deterministic set of RIBA Validation criteria currently in use in many schools. The framework should be reference point for a well-balanced curriculum, setting the scene for learning for uncertainty, not a schedule of what is to be learnt. Like the old adage often used in studio, that constrained sites offer a better foothold for creativity, it is our thesis that carefully considered constraints, constraints that address learning from past
experiments in education, both of our own and others, and are designed to help students address their ‘Fear of freedom’ (Freire, 1981) perhaps paradoxically, offer a degree of empowerment.

REFERENCES


Leski, K., 2015. The Storm of Creativity. MIT, Cambridge MA.


Negative capability in the design studio

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“We are searching for some kind of harmony between two intangibles: a form which we have not yet designed and a context which we cannot properly describe.”
Christopher Alexander (1964)

INTRODUCTION
Most artists and designers will admit that some of their greatest innovations and achievements are the result of an accident. This fortuitous sort of accident however, typically happens only after an extensive period of trial and error. A seasoned designer knows that a certain amount of frustration and chaos must be endured in this process before such luck can be gainfully procured, but for students who are new to the design process, these states of confusion and unknowing can be unnerving if not intolerable.

Accidents are unintentional by nature; they happen unexpectedly, outside one’s sense of control. The ability to perceive, think and function beyond a fixed capacity (or control) is also known as negative capability. The poet John Keats first used this term when trying to describe a person's openness or receptiveness to a reality that extends beyond the confines of his or her knowledge. Since then, the term has been appropriated by philosophers and other theorists who seek alternatives to the ongoing dialectic between structure and agency.

The concept of negative capability has a direct relationship to what design researchers Meinel and Leifer (2015, p. 4) refer to as The Ambiguity Rule, which states: “Innovation demands experimentation at the limits of our knowledge, at the limits of our ability to control event, and with the freedom to see things differently.” As design educators, we can provide a structure or platform for students to experiment on their own, but how can we create a studio environment that encourages risk-taking, allows for error and teaches students to acknowledge and tolerate states of ambiguity; how can we teach them to hone their skills in negative capability?

FAIL BETTER (Beckett, 1984)
Every year incoming university students show up to class ready to succeed, ready to follow the well worn paths to knowledge and ready to achieve, but rarely are they ready to fail. In fact, the fear of failure can be so paralyzing that it can keep some students from making a dedicated attempt. In some ways this is no surprise, students are rarely shown examples of failures by well-known artists and designers don’t often disclose their foibles. Resistance
to failure is a natural component of healthy behavior, but in its extreme condition it keeps students from learning what is perhaps the most valuable of all lessons – resilience. And for the creative disciplines, which value divergent thinking, a certain amount of risk-taking is an essential part of the practice.

Setting a classroom environment that is both rigorous on the one hand and permissive on the other is not an easy task for instructors. Permission must be granted to make mistakes while maintaining the expectation for hard work, quality work and critical analysis. Initial discussions around these subjects can help set the appropriate tone, one that normalizes accidents, mistakes and failure while it calls for diligence, insight and courage.

In 1973 artist Agnes Martin spoke to students at University of Pennsylvania about the importance of failure:

“I will speak later about successful works of art, but here I want to speak of failures. Failures that should be discarded and completely cut off. I have come especially to talk to those among you who recognize all of their failures and feel inadequate and defeated, to those who feel insufficient-- short of what is expected or needed. I would like somehow to explain that these feelings are the natural state of mind of the artist, that a sense of disappointment and defeat is the essential state of mind for creative work.” (Martin, 1993, pp.68-69).

She goes on to talk about the feelings of joy that come from an awareness of perfection in the mind—feelings that are connected to our experience of happiness and inspiration. But, she says, “we must surrender the idea that this perfection that we see in the mind or before our eyes is obtainable.” In truth, the more we are aware of perfection, the more we realize how unattainable it is. That’s why design is so difficult— one is constantly working through disappointments and failure to the point of defeat. “But still one wakes up in the morning and there is inspiration and one goes on”, Martin assures us. As one accepts failure, there must still be a determination to continue.

Reading and discussing these ideas in class can help set a tone for hard work and experimental trial and error. It sets an expectation not only for failure and defeat, but also resilience and tenacity. And beginning designers need to be prepared for failure if they want to achieve success later on. This paper outlines three strategies for teaching risk-adverse students in order to help them understand and endure the nature of ambiguity in the design process. The first two assignments, which were developed for first-year foundation level students, emphasize improvisation while they investigate unfamiliar modes of perception. The diversity of outcomes from these activities confirms the substance of individuality and can help teachers determine the best way to accommodate different learning styles. The last example (Leap Across Gaps) is a semester long project designed for second-year architectural design students and focuses on representational translations in space.

I. Draw with Closed Eyes
First year design classes typically offer highly structured assignments, many of which are meant to breakdown students’ preconceived notions of perception and representation. The emphasis in these assignments is on investigation and exploration rather than instruction. In other words, a limitation is prescribed, one that is often perceived as insurmountable, and the main goal is to initiate a process of discovery and invention. Blind contour drawing— or “pure contour drawing” as it was first popularized by Betty Edwards (Edwards)— is a method that prohibits the artist from looking at the paper that they are drawing on.
Numerous variations of this assignment exist. The two outlined here focus on selective observation and touch. Both assignments are self-portraits, the first asks students to look in a mirror and draw what they see without looking at the paper. Students must keep their eyes on the mirror and move their pencils continually on the page for 20 minutes. Some students use a draped piece of fabric or paper to help eliminate the temptation to look. Predictably, 20 minutes feels longer than expected, so students are encouraged to draw slowly and deliberately, taking their time to discover new and unexpected features. While the students are drawing, it’s important to emphasize that for this particular exercise, observation is more important than representation.

With pencil and paper ready, the second assignment asks students to close their eyes entirely and draw their face by touch only, so that one hand is drawing while the other hand is feeling the shapes, features and textures of the face. Once again they are asked to do this for up to 20 minutes, taking their time to feel not only the haptic features of their face but the tactile movement of their drawing utensil and paper.

The initial frustration of not seeing their drawing in progress, usually subsides as students begin to concentrate on the task at hand. Once a student starts to lose self-consciousness and surrender to the process, some remarkably original and creative results can occur. Below are a few examples of blind drawings that illustrate the openness of forms and variation of marks that typically result from this assignment. Students are quite amused when they first see their blind drawings, surprised at the unexpected results. But there is also a dissociative pleasure that can occur—the realization that something quite out of the ordinary, and beyond expectation can be created when one is willing to let go of intentions and become immersed in a process with careful attention.

After pinning the work up for review, instructors can recognize the individual styles for learning and expression. The perfectionist will typically use smaller, lightweight lines, with an approach that is dominated by hesitation, risk aversion, neatness and calculated precision. The expressionist will employ larger heavily weighted lines and marks that have a wide range of diversity. Their approach is more spontaneous, bold and muscular. Both styles have something positive to offer, and both have something to glean from the other. Understanding these differences can help instructors tailor their feedback to the needs of the student.

Students may not see the value in these awkward blind drawings at first, so it is important
to point them out. Identify the difference between open and closed forms, for instance, and variations in line quality and fluidity. Draw attention to the expressive moments that can happen unwittingly and remind students that some of our greatest discoveries and inventions are the result of an accident.

II. Play with Objects
According to the architect Yona Friedman (Obrist, 2007), “Intelligence starts with improvisation.” It is this act of uncertainty that prompts the vigilant search through complicated arrangements and situations. Getting students to improvise in beginning design classes can be challenging, especially with young adults who harbor self-conscious inhibitions. Exercises that take the form of a game break down inhibitions while they facilitate engagement and collaboration. In this way games are useful in foundation classes.

In this assignment students are asked to revisit the classic childhood pastime—playing with blocks. At the beginning of the semester, students are asked to fill a shoebox with regular and irregular wooden blocks, panels, rods, and found objects. It is important that the materials in the box are modular and reconfigurable. Other than that the only rule is that some of the blocks be the same size and all the materials fit together neatly in the box. The course it is developed for, Introduction to Architecture Design and Graphics, teaches students principal architectural drawing techniques and creation in space. This eclectic kit-of-parts is used throughout the duration of the course to teach the students about composition, representation, drawing systems and design thinking.

Using this kit-of-parts, collaborative warm-up exercises are structured to initiate
communication and exchange between the students. The task is straightforward: on a 18x24” sheet of paper, create a sculptural composition with your kit that explores the elements of composition (solid-void relationships, repetition, balance, tension, focal point). Once this is constructed, students swap places with one another to respond, revise and rearrange their peer’s piece. This continues until each student moves at least five times, providing multiple opportunities for improvisational revisions.

The act of playing is an essentially pleasant, engaging experience, but it can also be precarious and full of risk. For small children play comes naturally and usually involves the body and the manipulation of objects in space. The risks on a playground are mostly physical and emotional. As one matures, language and other complex instruments enter the playground and the risks become more social and psychological—there’s the risk of being misunderstood, the humiliation of defeat, or the embarrassment of undue exposure. But when one is subsumed in the act of playing, no matter what the age, inhibitions tend to fall away as a sense of freedom, spontaneity, and possibility unfold. At least this is what one hopes for. Returning to a childhood pastime with the inquiring mind of an academic can help students rediscover the moments of creativity and invention they enjoyed as children, giving them access to their inherent capacities as adults.

III. Leap Across Gaps

Second-year university students begin to develop visual communication skills and more confidence. But the design studio continues to be full of risk and uncertainty, as it should be. This next semester-long project, first developed by Sigrid Miller Pollin in 2005, begins with a handshake and ends with a building design. For most students, this is the first class in which they learn how to translate art and forms into architecture and buildings. The semester is organized into five projects that are sequential and conceptually linked. At each juncture, students must leap across a gap of not-knowing.

1. THE HANDSHAKE

After researching the photography sequences of Eadweard Muybridge, students are asked to choose a partner and choreograph a handshake that they must then document with a series of photographs. With this everyday symbolic gesture, students pay attention to the way social interaction occurs as movement through space. After the sequence is composed (some of which are quite fancy), teams partner with other teams to share and document the handshake sequences they’ve created. Once the series is printed and hung, students present their series along with an articulated term that describes their relational concept, such as interlocking, intertwining, compression, extension, joining, etc. These concept terms have great importance because they anchor the student’s investigations throughout the semester.

2. THE DYNAMIC DRAWING
In the next part of the project, students are asked to work individually to translate the handshake series into an abstract *Dynamic Drawing*. Here they are introduced to the first leap—how to translate familiar objects moving through space into an abstract drawing that communicates their conceptual term. The important part of this exercise is to encourage students to think abstractly about form—to extract a geometrical form out of a representational image. For reference, they are shown examples of the early 20th century cubist artists—like Braque, Picasso and Gris—who were fascinated with the possibilities that exist between time, space and the 2-dimensional image.

3. THE DUALITY CUBE

The next leap is a big one. The students—having distilled time, movement and space into a 2-dimensional abstract drawing—must translate (or interpret) their drawings and concepts into a 4x4x4" orthographic cube using two different materials. The two materials must be formed into two masses that can come apart and fit together—much like the original handshake. This cube explores the formal relationships between two common building materials—concrete and wood.

To begin this leap, students are asked to make 3D sketches. The guidelines for this step are explicit: "the two materials should be 1/16", 1/8" or 3/16" thick board materials (chipboard, cardboard, butter board). Although one material may dominate the model, the maximum difference should not be more than 60/40. All forms should be orthographic. Two voids (or more) must be incorporated into the cube. If possible, these voids should play a role in the overall meaning/ideas you are exploring on this project. One void should engage an outside plane and the other void should be inside your form (buried or hidden). They may be connected or autonomous, similar-sized or different. The voids should not be smaller than 1". Create at least 2 study models. These study models should be made quickly. They may be held together with white glue or tape (Miller Pollin, 2005).

The objective for these study models is to quickly discover potential configurations. There are many entry points for this translation. For instance, students can photocopy their *Dynamic Drawing*, cut it into 6" strips and begin to wrap it around a cube to see what ideas emerge. Or they can return to the photo series of the handshake to look for ideas about creating a joint relationship between differing materials. In all cases the concept idea that came from the photos and drawings (i.e. intertwining) are meant to guide the process.

Although the guidelines for this assignment are very prescribed— with specific materials,
dimensions, and requirements—many students still find this step difficult and confusing. Invariably there are those who want to know the correct way to do it. But as a problem with multiple (even infinite) solutions, and there is no one correct way, and each person will resolve it differently. Here the students must teach themselves how to do it through trial and error. They must wander intuitively from a place of not knowing to finding a form which can then be considered, rejected, revised or further developed. This place of not knowing is what the poet, John Keats (1877) refers to as “Negative Capability, that is, when a man is capable of being in uncertainties, mysteries, doubts, without any irritable reaching after fact and reason.” It is this receptive and searching state of mind that leads to innovation and discovery beyond one’s knowledge or perceived capacity.

As students find their way through this step, it is important for them to receive feedback and guidance not only from the instructor, but also from their classmates. Students learn the most from seeing the various ways their classmates tackle the problem. The early, rough unresolved sketches have as much to reveal about process as the more polished models. Here students experience first hand that good designs can emerge from not-so-good designs, and great designs can come out of those that are mediocre. This is an important point to emphasize because many students get frustrated if their models are not working well. Some feel exasperated over having to make and re-make models and drawings. They feel they have already made a decent sketch and that it is enough. What they need to understand is that great designers revise their ideas and models over and over and over again. It is through this revision process that one begins understand why certain designs work or don’t work. This is a kind of knowing that can’t be learned any other way; it cannot be taught, described or formulated—it must be experienced and weighed by each individual maker.

4. ROCKITE AND WOOD

Before the students move on to the concrete/wood edition of their cube, they are shown exemplary projects from previous years and asked to rethink their models. More advanced students who have completed this course are invited to come back and share their

\[\text{Figure 5 Duality Cube: showing progress of 3 sketch models from left to right. By student, Coleman Barnes}\]
knowledge from past experience. This includes giving a demonstration of mold-making for the concrete (Rockite) and some tips on crafting the wood to fit into the concrete. In the end, students who have taken the opportunity to revise their ideas in the previous step, typically make projects that are more interesting, complex and well thought out.

5. THE PROGRAM

The final leap integrates and transforms the cube into an architectural model and design. Here students are given a detailed program and asked to translate their cube into a design for an artist's studio and gallery. As they continue to explore the interplay of dualities—two forms, solid-void, two materials, two qualities—they learn to link concept, form, program and material. Once again students are given explicit guidelines for the assignment and once again they begin the process with sketches and study models. The cube acts as a foundation for their designs as they translate the material and spatial configuration to accommodate the program. Students are allowed to take liberties in the translation of the cube to a habitable space, but the overall composition of the design must be consistent with a single configuration of their cube's into two parts. For their final evaluations students must present a $\frac{1}{4}$" scale model of their design along with plans, elevations, sections, interior views, light studies, and a concept statement.

Students begin this task by exploring the various interconnected configurations for the two parts of their cube. The goal for this project is to find an appropriate spatial configuration for the program that best expresses their relational concept (i.e. intertwining). The designs they come up with are meant to build on the insights of earlier projects while they explore the qualities of material and light. It is a rigorous and demanding task to finish all the requirements in the allotted time. Students learn how to think spatially as they translate their designs between two and three-dimensional representation.

At crunch-time, students feel pressure and stress that they won’t be able to complete the requirements on time. Some express over-whelming feelings of frustration, confusion and
dismay— at which point they should be reminded that perfection is not expected, that perfection is unattainable, and that they should improvise to the best of their ability. In this way they can receive useful and timely feedback that will help their projects progress.

For the final reviews, students present their sequential explorations from the entire semester, including process sketches and models. The projects vary in comprehensive quality. Often there is a wide range in quality within one student’s presentation. A project with an outstanding model, for instance, may present weaker drawings, while one with exemplary drawings may have a less developed model, but a wonderfully articulated concept statement. Because the task is so demanding for the allotted time (about one month), students must decide how and where to focus their energy. What is most important is that they can see for themselves how design can begin with something as simple and ordinary as a handshake and end with a design for a habitable building; how forms and concepts can be extracted from one thing and transformed into another. They also recognize the ability of a building design to extend and express relational concepts like intertwining, compression, or joining.

CONCLUSION

The assignments outlined above are presented for educators who are interested in creating a studio environment that values inquiry over knowledge. Like many studio assignments, they have evolved as they’re passed down from one teacher to the next. By nature, they are meant to be adopted, shared, revised or reworked. As the editors of Paper Monument point out:

“There can be legendary assignments, attributed to legendary teachers, but few people would consider it improper to re-use them. Just like the jokes that assignments sometimes resemble, a lot depends on the telling. Likewise, if assignments are like prescriptions or recipes, it’s crucial to know what the ailment is or who is coming for dinner.” (Petrovich and White, 2012).

Draw with Closed Eyes; Play with Objects; Leap Across Gaps – these are all calls for action
that involve risk- the risk of losing control, the risk of judgment, the risk of making mistakes, of rejection, of failure or absurdity. As such, these calls for action are good prescriptions for risk-adverse students. Being a perfectionist certainly has its advantages, especially in the final stages of design, but in the beginning stages, the expectations a perfectionist harbors can hinder the creative process.

The first exercise forces students to let go of perfection, to close their eyes to what they know they can do and pay attention to alternative modes of perception- like touch, movement and spatial flow- revealing how innovative and original creations can result from unintentional actions. The second revisits a playful childhood pastime, reminding them of their innate creative abilities. This cultivates a climate of experimentation and collaboration in the classroom. The third example benefits more experienced students, challenging them to leap across the interstitial gaps of knowledge and instruction. It promotes trial and error, which is the fundamental method of solving problems through repeated, varied and failed attempts.

One should not expect to play beautiful music the first time an instrument is picked up. Likewise, students should know they are not expected to create a masterpiece, at least not in the beginning. And they should be open to accidental discoveries along the way. Together these projects help teach students the benefits of negative capability in studio environments. They show that control, assessment and judgment need to be suspended in the early stages of design for divergent thinking to manifest. Most importantly, they can help students understand and accept that uncertainty and failure in the design process is not only inevitable, but one that is integral to creative practice.

REFERENCES

Miller Pollin, S., 2005, Project sequence for sophomore Design 1 studio course, Department of Architecture, University of Massachusetts Amherst, unpublished.
Goodbye Mister Bond: 007’s critical advocacy for feminism & modernism

Dr. Harriet Harriss
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INTRODUCTION

It’s not just villains that are fond of saying, “goodbye mister Bond”. Any viewer mindful of prejudice is likely to have wished that he - or rather his casually misogynistic attitudes to women – could get killed off on occasion, too. And yet, could James Bond be considered to be both a feminist and modernist advocate? If not, then why would the author - an architect and a feminist - find the way in which both women and modernist buildings are represented in all 24 Bond films politically affirming and even professionally inspiring - as opposed to simply sexist or oppressive (Funnell, 2011)? In the spirit of auto-ethnographic curiosity (Chang, 2008), this paper considers whether the way in which Bond films represent both women and modernist architecture amounts to negative stereotyping, or if they offer instead a critique of their mutually problematised status within society.

RISKY WOMEN

Whilst author Ian Fleming’s James Bond character has long been vilified as a sexist, the cinematic franchise continues smash box office records (Ashton, 2015). But what is it about the Bond franchise that women find appealing?. More recent iterations have seen the Bond character manifest “endearing cracks” and “weaknesses” (Cox, 2015), not unlike a concrete edifice, gently degrading. Previously it has been argued that the Bond series strategically incorporates second-wave feminist discourses, not as a means to alter Bond’s attitude to women, but rather, to alter the attitudes of the women around him to Bond (Chapman, 2000). However, this analysis fails to take into account the possibility that women might not be tuning in because they’re interested in Bond, but because they’re interested in Bond ‘girls’ (or rather women) instead. Because whilst the immutably misogynist Bond sets an unachievable, hyper-masculine and even misandrous ideal for most men, female audiences are, in contrast, offered a far greater confection of complex and brilliant female characters to identify with. Overall in fact, Bond women are portrayed as unrelentingly brilliant: displaying substantial skills in hand-to-hand combat (From Russia With Love, 1963), poly-linguistics & HMRC treasury duties (Eva Green speaks three languages; French, English and Swedish), nuclear-physics (such as ‘Dr Christmas Jones’ in The World is not Enough, 1999), geo-political expertise, as well as demonstrating a tenacious ability to survive a perilous existence through timely shifts in allegiance to the winning team. So what is it about them that prove to be so compelling? And from the auto-ethnographic perspective of an architect and feminist, so professionally affirming? If the latter is true, what are the origins of these parallels exactly?
“YOU ALWAYS WERE A CUNNING LINGUIST, JAMES” (TOMORROW NEVER DIES, 1997)

For many commentators, the names of some of the Bond Women such as Pussy Galore, Xenia Onatopp, Honey Rider, Octopussy, Plenty-O-Toole & Holly Goodhead, are viewed as demeaning to women due to their sexual overtones (Angelsey, 2012). However, a study into the etymological, lexical and phonological associations of Bond women’s names reveals their purpose to allude to more complex plot narratives (Vikstrand, 2006) or each character’s multiple and often contrasting identities. To perceive them as purely “disposable pleasures rather than meaningful pursuits”, as Bond woman Vesper Lynd points out in Casino Royale (2006), is to underestimate them, with typically fatal consequences - three quarters of the 44 women Bond has slept with have tried to kill him – regardless of whether they were coitally claimed by him or not (Stokes, 2008). Subsequently, one might assume that Ian Fleming’s decision to name Bond after, “the simplest, dullest, plainest-sounding name” he could find (Sterling & Morecambe, 2003) was partly motivated by a desire to create a blank screen onto which the complex lives of the female characters could be more effectively projected. This advances Kingsley Amis’s view - captured in his 1965 book entitled, The Bond Dossier (Amis, 1965) – that Bond has no inner life in Fleming’s novels, so any opinions we give to him are our own projections. In either scenario, Bond’s ‘blankness’ resembles the ‘blank canvas’ or tabula rasa associated with the large slab of white-rendered walls favoured by early modernist architects.

EXPENDABLE WOMEN, INCREMENTAL CHANGE

Of course, not all Bond Women are given explicitly sexualised names. Thunderball’s (1965) Dominetta Vitali - described by Fleming as, “an independent, a girl of authority and character” (Fleming, 1961) – takes her name from the term ‘dominus ’ meaning lord & master’ (Vikstrand, 2006). And whilst Fleming always described ‘M’ as a male character in his books, the directors took the canonically questionable decision to make ‘M’ a female in Goldeneye (1995) until Quantum of Solace (2008), a decision assumed to reflect the appointment of the real-life head of MI5 – Stella Rimington, (West, 2010). Revealingly however, ‘M’ was in fact Fleming’s nickname for his own mother (Sterling & Morecambe (2003), which perhaps explains why ‘M’ is the only character to whom James Bond is ever accountable. Indeed, Judy Dench’s portrayal of ‘M’ was described as that of a, ‘tough yet occasionally tender’ boss (Child, 2012) – and even a working mother. And yet, Dench’s ‘M’ has been viewed as a departure from the usual ageist stereotypes, which portray older women as, “sick, sexless, uninvolved and alone,” (Payne & Wittington, 1976). In killing off ‘M’ in Quantum of Solace - the ultimate act of Oedipal matricide – Bond is finally cut loose from the apron springs and literally turns feral - working outside of MI6. Perhaps this accounts for why he hooks up with an ‘older’ Bond woman, Lucia Sciarra, in the subsequent film (Spectre, 2015), as if as a gesture of maternal longing. In this, the most recent Bond film, representations of women have generally been reported as having improved (Lee, 2015). For example, the afore mentioned Lucia Sciarra is a Mafiosa queen unafraid of leading a large team of men; Miss Moneypenny has graduated from a secretarial wife to counsel and capable agent in her own right (Skyfall, 2012); psychologist Dr Madeleine Swann only adheres to the Bond-smitten stereotype when he subjects her to a co-dependent relationship – by bringing harm into her life and then protecting her from it; and the mysterious Mexican ‘Estrella’, while limited to being Bond’s plus-one during the Day of the Dead party, avoids the tradition of being killed off when someone more intriguing comes along. But is this true progress? Not really. Bond has always dated brilliant women who consistently and repeatedly, “put Bond in his place” (McGowan, 2010) despite their apparent – or possibly intentional – disposability (Over the course of the 23 James Bond films, Bond has sex with 55 women. Seventeen of the 55 end up dead).
Indeed, whilst the women are becoming more certain of themselves, Bond’s attitude to women seems generally unchanged. The message to women is clear: progress is being made, but it is incremental. However, if misrepresenting women “once is happenstance. Twice is coincidence. Three times is enemy action”, then perhaps we should take author Ian Fleming at his word (Fleming, 1959) and examine the matter further.

**RISKY MODERNISM**

It is not just women who struggle to survive an encounter with Bond. Many modern buildings...
suffer similarly too. In fact, the aspirations of most Bond villains - to improve humanity by inserting a rational, orderly utopia of their own design, (Rose, 2008) favouring a palette of concrete, steel and grand-scale fenestrations – are profoundly similar to those of many modernist architects. For example, Le Corbusier’s stated intention, “to create architecture... to create order,” (Le Corbusier, 1931), is echoed by Bond villain Elliot Carver’s ambition to, ‘launch a new world order’ in Tomorrow Never Dies (1997). Indeed, Bond villains, “neither express their roots in history nor attract the viewer with the splendour of intricate facades,” (Greinacher, 2012) preferring the, “somewhat frightening sign of progress driven by technological and scientific advances,” embodied in the international style (Rosa, 2000).

The majority of Bond films depict the villain’s lair in either appropriate key modernist buildings – such as architect Lautner’s Elrod House in Diamonds Are Forever (1971) [Fig 1] or the MI6 mole in Quantum of Solace (2008), who lives in London’s Barbican centre (Rose, 2008) [Fig 2], or resort to conspicuously derivative film sets. Examples of the latter include Dr No’s command centre [Fig 3], resembling Albert Kahn’s designs for industry (Greinacher, 2012) [Fig 4]; Osato’s spacious office [Fig 5] in You Only Live Twice (1967) and Corbusier’s National Museum of Western Art in Tokyo [Fig 6], Japan; Goldfinger’s rumpus room’s [Fig 7] similarity to Frank Lloyd Wright Rosenbaum House [Fig 8] and Hugo Drax’s behind-the-waterfall lair in Moonraker [Fig 9], whose Mayan-patterned relief panels resemble those of Wright’s Ennis House (Rose, 2008) [Fig 10].

However, it isn’t only modernist buildings that are appropriated by and associated with villainous activities. That one of Bond’s most troubling villains was named after Erno Goldfinger was no coincidence. It was widely known that Fleming held ‘scathing views’ against modernism and was renowned for generally naming villains after living people (not just architects) with whom he’d developed a negative association (Rose, 2008).
Interestingly, some of Goldfinger’s rare post-war private houses shared the same fate as the modern architecture depicted in the Bond films, and one of the most significant of his private residences was demolished to make way for a bungalow (Fisher, 1998, cited in Greinacher, 2012). In much the same way that the plainness of Bond’s name acts as an unremarkable blank canvas upon which the more complex female characters concerns are projected, Fleming similarly chose to situate Bond in ‘unremarkable’ accommodation, featuring “combinations of French Empire, English mid-Georgian, but very few Regency touches” (Snadon, 2012) [Fig 11]. This creative disregard for Bond’s interiors stands in stark opposition to the, “detailed and prominently featured” architectural interiors of his villains (Greinacher, 2012). What Bond (or his interiors) seem to stand for are out-dated, traditional values, which one could easily align with his similarly out-dated attitudes to women. But are these really Bond’s values? After all, he seldom spends time at home and instead endlessly covets the modern lifestyles and locations of his catalogue of nemeses. Perhaps his desire to destroy them is more about his out-of-control and consistently thwarted longing to possess them, rather than his disdain. Arguably, this principle could easily be applied to the women in his life.

**A WOMAN’S PLACE IS IN THE VILLAINOUS DOMESTIC INTERIOR**

Bond villain domains form a backdrop against which many common domestic anxieties are explored, particularly in relation to women’s confinement within the home. For example, the villain’s lair is typically isolated, thereby forcing intimacy between the villain and his mercurial and often reluctant girlfriends - invariably requiring Bond to engage in acts of rescue. As Dr No put it, “together, that is sovereignty. The world is too public. And how
do I possess that power? Through privacy” (Fleming, 2002). The desire to simultaneously achieve “togetherness” and “privacy” is of course a conundrum faced by most nuclear families and spawned the drive towards suburban isolation – against which teenagers, seemingly much like Bond – have attempted to rebel. The conflict between longing for both “togetherness” and “privacy” is what Richard Sennett discusses in The Brutality of Modern Families (Sennett, 1970), arguing that the emphasis on privacy underpinning the nuclear family impacts negatively upon the “civilising possibilities that a metropolis uniquely offers [that] are disappearing” (Sennett, 1970). Arguably, both togetherness and privacy are more likely to be achieved, for better or for worse, within a high-density modernist housing block, than in a remote suburban retreat (Lawson, 2009).

According to Udo Greinacher, Bond villains’ homes are “designed to dominate from within” (Greinacher, 2012): from the “female territory” of the interior (Havenhand, 2004). In much the same way that feminist writers have described women’s domestic status as housewives (Franck & Paxson, 1989; Gordon, 1996; Floyd, 1999) as “guardians of aesthetic values” (McLaren, 2015), Bond villain interiors are often protected by women, as most strikingly exemplified by the expulsion of Bond by Bambi and Thumper in Diamonds are Forever (1971) [Fig 12]. In addition to the conceptual conflation of women’s bodies and interiors (Gordon, 1996), the psycho-sexual symbolism of Bond’s unwelcome ‘invasion’ into the (male) villains metaphorical interior feature in queer theory analyses of the Bond Genre (Stegall and Edwards, 2009; Miller, 2001) extending his modernist longings towards contemporary definitions of metro-sexuality.

DIEGETIC DOMESTIC TECHNOLOGIES & OIKOPHOBIA

Bond villains’ interiors seem generally inclined towards the fetishisation of technology. Indeed, the “technological advances and functional designs” (Greinacher, 2012) depicted in these interiors, appear to perpetuate the myth that technological progress produces household appliances that sufficiently liberate women from their domestic duties and enable them to enter the workplace (Lupton, 1993). But do they? When Bond villains’ ‘domestic appliances’ turn hostile and are even used against the villains themselves, female viewers are invited to indulge their oikophobic (an aversion to home surroundings) anxieties. For example, the villain Renard is killed by his own Plutonium reactor in The World Is Not Enough (1999); Alec Trevelyan breaks his back on his own satellite dish and is then crushed to death by a falling antenna in Goldeneye (1995) [Fig 13]; and Dr No, who boils to death in his own cooling vat (1962), tacitly conveying that any attempts to subvert modernism’s pure aesthetics with contaminating technologies comes at a deadly cost. In light of this, Ozenfant and Le Corbusier’s description of modernism as being, “the vacuum cleaning period of architecture” seems to take on new and even acerbic meaning (Jencks, 2002). Similarly, when villains attempt to subvert modernism’s constrained palette by inserting ‘natural’ elements into the minimalistic interiors, decorative aquariums transmogrify into shark tanks (The Spy Who Loved Me, 1977; Thunderball, 1965) and Piranha pools (You Only Live Twice, 1967) [Fig 14], and the architecture become retaliatory. Subsequently, from an architectural history perspective, one could construe this as a resistance not only to subverted aesthetics but also to High-Tech architecture, which emerged from Modernism in the late 1960s.

For the average woman viewer with domestic duties, however, these technology-infused interiors play out the dichotomy between technological terrorisation versus domestic drudgery - but from a safe distance. And whilst the majority of futuristic films fulfil their role in pre-conditioning audiences towards accepting advanced technological devices in outer space, Bond films focus on technologies that impact on the interior through diegetic
prototypes: visions of the future that help suspend our disbelief about change (Sterling, 2013). Subsequently, Bond films depict satellite TVs not dissimilar to today’s entertainment centres, comprehensive surveillance years in advance of domestic intercoms and baby monitors, and even introduce nuclear energy into the home, decades ahead of microwaves. It is intriguing that whilst Bond can handle any array of portable, non-domestic devices, from flying-shooting-submersible sports cars to mid-range missile fountain pens, the villains’ technologies prove more deadly than his own, and are frequently used by Bond against the villain. This message – pervasive in many forms of media from TV commercials and beyond - merely serves to affirm the domestic norm: that women assume primary responsibility for domestic life, rather than risk sharing them with their incompetent and even dangerous-to-domestically-equip male partners (Lupton, 1993).

PARALLELS WITH PRACTICE

As the evidence so far suggests, both the tacit feminist narratives and inverted modernist advocacy may account for why a feminist and an architect might be drawn to an otherwise overtly misogynist film franchise. But as many commentators have identified, these stereotypes still seem out-dated. What is it therefore that feels pertinent and even applicable the circumstances of a woman in architectural practice today? Could direct comparisons be made between the status of women in architecture and Bond women? Or perhaps more poignantly, could we better understand something of the current professional conditions of architectural practice, via a thorough scrutiny of the troubling appeal of James Bond? Let’s look at the points of likely comparison. Firstly, statistics from the UK Fees Bureau (2016) show only 22% of the profession is female, and twice as many women architects are unemployed compared to men. In effect, both Bond women and women architects form a marginal interest in proportion to the considered importance of the activities of men. Secondly, in much the same way that Bond usually gets through several women in one film, women architects are more likely to take on part-time roles due to parenting career breaks and are further disadvantaged by doing this against the backdrop of a long working hours practice culture (Mark, 2015). In terms of pay differentials, the average male architect earns 18 per cent more than the average female (Fees Bureau, 2016) even though they possess the same skills. As examined previously, many Bond women display capabilities equal to Bond, but arguably these skills – diplomacy, advanced accountancy, bad client/boss/contractor management expertise to name a few – seem far more pertinent to the practice of architecture - or espionage - than those of bombastic Bond. Indeed, Bond’s contradictions around the need to be both a ‘predator’ and a ‘gentleman’ (Arp & Decker, 2006; Taliaferro & Le Gall, 2006) are not dissimilar to the need for architects to resolve both their commercial interests with their ethical ones. And much like Bond’s ‘disposable’ women, more female than male architects were made redundant during the last recession (Hopkirk, 2012) in addition to those who simply leave the profession after a few years in practice of their own volition (Duncan, 2013) - most often citing endemic sexism and concerns over childcare than any lack of interest in the work.

Seemingly, the women who succeed in Bond films have learned to adopt a status of sexual ‘ambiguity’ as means to survive (Ladenson, 2001), in much the same way a female architect might feel the need to conceal or play down her familial or maternal status or responsibilities. Although Dench’s M reveals she’s a working mother, the maternal status of the women Bond sleeps with remain concealed. Indeed, despite all the unprotected sex Bond has, it seems remarkable that he produces only one son – with Kissy Suzuki – a detail in Fleming’s novel You Only Live Twice (1964), one that, unsurprisingly didn’t
make it into the film version in 1967. In general, the fade-to-black cinematic convention supposedly alludes to the possibility of sexual intimacy, and is sometimes used in Bond films as a means to moderate the many sex scenes. But as any ‘working-mother’ architect will tell you, ‘fade to black’ doesn’t imply you’re sleeping with the boss, it simply means that you’re too exhausted to contemplate nocturnal adult interactions in the bandwidth between finishing at work and waking up before the children, in order to prep for an early site meeting. Overall, the parallels between architects in practice and women in Bond films share two core principles; that underrepresentation perpetuates disadvantage and that very little seems to ever change.

CONCLUSION

So do Bond movies really rail against modernism & women as previously assumed? For some proponents of the Bond genre, Bond’s attitudes merely reflect – rather than direct - public perception of both women and modernist buildings. However, as this analysis has illustrated, by attempting to make an enemy of both architecture and women, a political and even aesthetic empathy can be discerned. In other words, Bond’s routine annihilation of both women and modern architecture be understood less as a grudge against modern architecture and instead - an extreme yet galvanising form of critical ‘consciencization’ (Friere, 1968) that, “liberates human beings from the circumstances that enslave them” (Horkheimer 1982). In effect, by aligning the plight of modernist buildings to that of Bond women, it could instead be construed that Bond films offer a tacit advocacy of the position of both within society. Where the real critique is focussed it seems, is upon Bond’s ‘traditional’ values and aesthetic origins. Furthermore, in asking, “why does saving the world necessitate the demolition of meticulously designed hideouts that display amenities & technology not available to most of us?” (Greinacher, 2012), leaving the viewer to wonder whether this is a petition against affluence and not just aesthetics. Subsequently, the flooding, setting alight and exploding of modern buildings can instead be construed as an act against socio-economic exclusion, rather than an act against architecture. Indeed, the “endearingly cracked” (Cox, 2015) character of James Bond cannot be fixed by women anymore than the problem of women in architecture become fixed by women-appeasing male architects. Perhaps - as Bond’s name implies, these cracks can only be ‘bonded’ together by the man himself.

REFERENCES

Angelsey, S., (2012) 007 or Oh! Oh! Oh!? Are these names Bond Girls or Porn Stars?, Daily Mirror Newspaper, Oct 12, 2012
Cox, T., (2015) Every woman wants one night with Bond, MAILONLINE, 26 October 2015
Duncan, J.' (2013) Why are so many women leaving architecture? Guardian Online, Wednesday 7 August 2013
Fleming, I. , (1956), Moonraker, Jonathan Cape Publishers
Fleming, I., (1956) Diamonds are Forever, Jonathan Cape Publishers
Fleming, I.,(1958) Dr No, Jonathan Cape Publishers
Fleming, I.,(1961) Thunderball, Jonathan Cape Publishers
Fleming, I.,(1965) You Only Live Twice, Jonathan Cape Publishers
Fleming, I.,(1967) From Russia with Love, Jonathan Cape Publishers


CINEMATOGRAPHY

Diamonds are Forever, (1971), Dir. Hamilton, G.

Dr No, (1962), Dir. Young, T.

Goldeneye, (1995), Dir. Campbell, M.

Moonraker, (1979), Dir. Gilbert, L.

Quantum of Solace, (2008), Dir. Forster, M.

Russia with Love, (1963), Dir. Young, T.

Skyfall, (2012) Dir. Mendes, S.

The Spy Who Loved me, (1977), Dir. Gilbert, L.

The World is Not Enough, (1999), Dir. Apted, M.

Thunderball, (1965), Dir. Young, T.

Tomorrow never dies, (1997) Dir, Spottiswoode, R.

You Only Live Twice, (1967), Dir. Gilbert, L.
Tactics developed in times of economic crisis applied in design studios

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ABSTRACT

Crisis: Turning point in a disease [for better or worse] - Hippocrates

Previous economic growth and the relatively low number of practicing professionals in Portugal allowed architects such as Álvaro Siza (2012) to work mainly through commissions made by government entities. According to Costa (2013), the international recognition of these architects led to an influx of students into architecture schools. Recent research (Caldeira, Santos and Ravara, 2013) shows that an excessive number of recently graduated architects together with the decline in the construction industry gave rise to high unemployment rates among Portuguese architects.

Some of them, consciously or not, went looking for work in the fringes of the discipline. They are characterised by a multitude of attitudes working on transdisciplinary projects. They do not have any commissions, they re-invent sustainable models leading to self-built, ephemeral constructions, minimal interventions without design, self project financing or fund raising. They are networked, grouping and ungrouping quickly not only locally but worldwide. Architect designed political interventions appear on the streets. Some embrace social causes and others design only digital projects.

If the architecture of the preceding generation was intended to last one hundred years or forever, now it is designed to last one week or never to be built allowing an increased design freedom. The building materials of the preceding generation were limited to stone, concrete, glass and wood. Now the range has been extended to plastic, earth, wax, mirrors, paper, live animals, ready-made and pixels. They ask themselves frequently what can we do with €500? Or what can we build in one week? They re-invent the meaning of the word architecture. Baptista (2010) suggests that this happens not because they don’t want to do the previous architecture, but because this is the only architecture they can do.

The architect’s practice and education needs to change not only to suit challenging economic times but due to restrictions of our finite world: super populated, connected, fully explored and with increasing levels of consumption. Students sometimes have expectations to design through massive amounts of material and human labour. This is an issue which will become increasingly difficult to do.
Learning with the Portuguese example we are applying their tactics in Design Studios in Austria and Australia, countries not hit by monetary constraints. Instead of asking students to draw proposals on paper or models, we ask them to actually build something with a low budget in a short time. Not models but 1/1 finished products that, due to their resource scarcity, will achieve maximum impact on their audience. The evanescent character of these proposals allows great freedom in students’ designs.

We ask students:
• What can you build with 100€?
• If you do it in a group will it be better?
• What materials can you cut, sew, weld, assemble?
• What can you build in one week?
• Is it Architecture?

With this hands-on approach, students understand quickly that their actions (sketches/ideas/proposals) have consequences (finished project/created atmosphere/audience perception), understanding the vertical connection between representation and a built project.

CONTEXT

Portugal had a construction boom that reached its peak in 2001 and has been declining ever since according to Gil and Ministro (2012). The country is currently in debt, with high levels of unemployment and an absence of resources. Cunha (2012) suggests that the word *austeridade* - austerity for the Portuguese - is equal to a rise in living costs that has consequences such as disease, malnutrition, low self-esteem and depression. Rights considered acquired are reduced - health, education, social benefits, unemployment benefits. Freedom of expression is further decreased in the media. Journalists are dismissed at Público (newspaper) and Lusa (news agency). Diário de Notícias, Jornal de Notícias and TSF are bought by the people they once criticised and who are connected to Angolan power. There is popular dissatisfaction and a widening in the gap between poor and rich.

Architects of the preceding generation (born in the 40s, 50s and 60s) were centred in the single author model with enduring offices and fixed jobs. They produced projects in their most classical sense: *Utilitas, Venustas, Firmitas*. Luís Tavares Pereira and Pedro Gadahno curated the 2004 Portuguese Official Representation at the Architecture Biennial of Venice: *Metaflux - Two Generations in Recent Portuguese Architecture*. Gadahno (2004) has categorised two generations of architects as X and Y with subtle differences:

“At first sight, it may seem surprising that questions of identity are raised regarding Portuguese architecture. In terms of global cartography, it not only belongs to the centre, but is also easily identifiable, specifically through some of its leading figures and major trends. As one of its truly exceptional figures has become part of the world star system, Portuguese architecture has guaranteed a wide recognition. Equally, as its nature was fleetingly legitimised by a critical discourse that came from the centre, it guaranteed an apparently secure identity niche.”

Luís Tavares Pereira and Pedro Gadahno where quite aware of the subtle differences between the X generation - Eduardo Souto de Moura, João Luís Carrilho da Graça, etc. - and the Y generation – Guedes + de Campos, Serôdio, Furtado e Associados, João Mendes Ribeiro, Promontório Arquitectos, Inês Lobo, as* atelier de santos, Bernardo Rodrigues, Nuno Brandão Costa, S’A Arquitectos. However, work methodologies of both
generations were the same and an outside observer could not read or understand other more understated differences.

Baptista (2007) started publishing Cadernos Geração Z in the architecture magazine Arq/a. Baptista attributed eight pages to each studio, which then had the freedom to publish whatever it wanted. Invited studios of the so-called Generation Z were: MOOV, Arquitectos Anônimos, Kaputt!, AUZprojekt, Embaixada, Extrastudio, Plano b, Red, FOR A, blaanc, André Campos + Joana Mendes, Extrastudio, Atelier Data, Ateliermob, dass and On-Office.

Baptista (2009) then pinpointed affirmative visible differences between this and previous generations:

“In general terms, the idea of generational change in Portuguese architecture manifests itself essentially through a progressive distancing of the younger generation in relation to the ideological conception and aesthetic that has characterized Portuguese contemporary architecture. In this sense, seeking to mark the shattering and dissipation of identities that support the specificity of Portuguese architecture. Essentially, this generational distinction aims to capture the change in attitude of younger architects, for whom earlier disciplinary dichotomies, to a large extent, no longer make sense or are operative. In fact, national vs. international, local vs. global, public vs. private, ethics vs. aesthetics, program vs. form, abstract vs. figurative are, for these emerging practices, no longer considered opposing or exclusive realities. For this reason, they assume above all, a more contaminant and hybrid positioning, adopting the most effective and resourceful creative strategies, taking into consideration the response to a specific situation. In fact, we cannot speak merely of programmatic, formal or aesthetic issues, but mostly about new approaches and working methods. This is clearly reflected in the changes in the ways of structuring studios, almost all of them adopt the form of a collective as well as the development of collaborations that cross multiple interests and disciplines from design to urban planning, through the human sciences and technological research.”

Baptista (2008): “Recent events led the new generation of Portuguese architects - published as Geração Z (Generation Z) - to develop work methodologies distinct from the previous generation.” It is exactly these different work methodologies that have been implemented in student design studios in Austria and Australia.

If the most obvious characteristic of the Geração Z studios is its diversity, what they have in common according to Gadanho (2010) is:

- Market: lack of commissions, having to work with low budgets, no fixed definitive employment.
- Mobility: They have experienced a no-borders Europe, Erasmus programs and low cost flights.
- Networks: Internet has allowed new partnerships with distant partners, access to international competitions, etc.
- Communication: New computer based representation skills.
- Pop: As in popular. Representative mechanisms to be considered by non-architects. Starting with Photoshop and doing away with the contamination of buildings. Instead of a coherent language it is varied from project to project.
- Nature: the goal is no longer a permanent building. Ephemeral actions and
performance-based projects are valid.

- **Attitude:** Architecture studios don’t have personal names anymore. They are acronyms or provocations hiding authorships. Architecture is no longer done by an author. It is a social act with multiple interactions.
- **Conscience:** A new attitude implies a new conscience. Social conscience, Political conscience.

**TACTICS**

We have looked into the work done by these Portuguese studios and organised their work methodologies into tactics possible to be applied in design studios:

1. **Positive Attitude**
   **Example:** MOOV was a small studio of three members. Their motto was “Say yes to everything”. No matter what your clients ask you to do - small renovations, factory buildings or a city - they just said yes to everything. The reason was tied to the very low ratio of client meetings and actual project conclusions. MOOV soon understood that they didn’t want to be the “delaying factor” in negotiations. Because of this, they simply said yes to everything. Only when the time was right and negotiations advanced, would they explain their conditions to customers. These conditions could range from payments to design ethics.

   **Relevance in student design studios:** A positive attitude allows students to aim for ambitious tasks that they wouldn't normally engage with. Protected by an academic environment, it is acceptable and desired that they aim high, sometimes achieving outstanding results and sometimes failing completely. Both situations are accepted equally. Failure is not only accepted but also encouraged. Furthermore, students are asked to define failure themselves, instead of letting other people decide for them. Once students lose the fear of failing they are ready to fully develop their capacities.

2. **Collective Authorship**
   **Example:** Kaputt! Arquitectura was a collective experience. A studio with an open-ended number of members. Depending on the conditions of the projects or members available, the number of members varied from three to sixteen. All members had the same relevance independent of their age or experience and all decisions were made in a group. Needless to say that they were all paid the same - when there was money. All ideas were collective: the sooner they forgot who initially had an idea, the sooner they could appropriate it, distort it, bend it, make it better and pass it to someone else. In the end, no one could trace back how an idea had materialised. It became collective.

   **Relevance in student design studios:** Methods for improved group work dynamics.

3. **Into the Streets**
   **Example:** Frequently, instead of waiting for clients, these studios went full on with a hands-on approach that normally implied an intervention in an urban setting sometimes in the realms of street artists such as graffiti artists, street poster designers and performance artists.

   **Relevance in student design studios:** Students are able to test their designs in a real life environment, having instantaneous user feedback from finished projects instead of speculating about projects that are only drawn on paper or screens.
4. Maximum Expression with Minimum Resources

Example: In 2007 Kaputt! Architecture was invited to produce four pages to be published in a magazine. Unusually the magazine offered €500 for the task. The following questions arose in the course of Kaputt! group meetings: Instead of publishing already existing material, would it be possible to do architecture with this budget? Not representations of a possible architecture but a physical object that could be called architecture? Inspired by an Enric Miralles photograph where he is looking through a model, they started the project Máscara de Iniciação (Figure 1) where the user wears architecture. The goal of the project wasn’t to impact external observers but to design how the user perceives the space around them. This instrument is not only a filter between the user and the space around them, but it also contains in itself internal spatial qualities. A micro architecture. Máscara de Iniciação is affirmatively asymmetric, not only its design but the experiences it provides. If with the left eye one can perceive the external world through an architectural composition, with the right eye one can perceive an interior space filled with natural sunlight that shifts as the wearer moves. The project was implemented in a short period of time with a limited budget. Once ready it was taken to the streets to be tested in an urban environment. The authors wore the instrument on the streets until security members asked them to stop, claiming “possible public disturbance” even if they couldn’t explain exactly what this disturbance was. Authors described the project intention as: “To understand in a more direct way how can Architecture design have a strong impact on our reading of the environment. To operate directly on the sensorial capacities of the individual.”

Applied in student design studios: The project was directly replicated at Innsbrück Universität, Austria in 2012. It was requested that the students design not a model but a finished product. A one-week project to “Design and build an instrument that alters the
perceived reality”, “Wearable at human scale” and to “take it into the city”. Students Andrea dal Negro and Simon Vettori studied African masks and noted that their strong presence is due to their rigid symmetry, un-proportionated dimensions and the fact that some parts of the body such as eyes and ears are not in their usual places. They chose to create a mask as symmetrical as possible on the exterior, but in a way that the user would experience an asymmetrical perception of the space around them (Figure. 2). To obtain this they quickly produced a cardboard prototype with multiple successions of asymmetrical mirrors in its interior. These mirrors not only altered the user’s vision but also altered the three-dimensionality of exterior objects. Inspired by filming processes from Alexander Sokurov’s (1999) *Mother and Son*, objects could become slightly flatter or completely flatter depending if they were seen through one or two mirrors. Sokurov used to film through successions of mirrors to obtain images unrealistically flattened. In the project’s next phase students used the laser cutter to obtain better finishes at scale 1/1.

In 2015 150 second year students from The University of Western Australia undertook a similar project. As second year students they had more time to design and produce the project: 5 weeks.

Jedenov (2015) wrote on the students’ brief: “To design and build an instrument - wearable design of scale 1/1 that significantly alters how we perceive the space around us. The design will interact with the user and somehow with possible viewers. Students will be invited to test the instrument in the city centre and document it in one short film. Again it is anticipated that students develop an idea as a group and further pursue it through a complete design cycle - from idea to finished product.

There will be:
• NO scale models
• NO regulations to be taken into account
• NO technical drawings

It is expected:
• Spatial creation
• Ideas
• Finished products of their real scale.”

With the same brief but different studio coordinators (Robert Cameron, Nicoletta Pizzuti, Devon Ward, Monia Allegre, Emily Van Eyck, Brad Ladyman, Catherine Lindsay), there was a variety results as some were interested in spatial qualities, others in mechanics and others in electronics.

A few example of student projects were:
• Floating helium supported video camera that allows user to view himself in plan
• Movement restriction and posture change instrument
• Condensation chamber
• Multiple vision
• Inflatable instrument activated by walking
• Arm extensors
• Ultra sound sensors full suit
• Electronic gloves that translate touch into sound
• Suits with destabilising integrated fluids
• Machine for private group conversations in public spaces
• Movement activated instruments
• Solar power activated instruments
• Atmospheric altering instruments
• Air quality prostheses

As an example: Yielding & Intimidation from Carrick Elliott: “The concept consisted of designing a method to make surrounding parties yield to the user. The design was centred around agonistic behaviour as seen in nature - similar to that of the frill-necked lizard”

To achieve this Elliot opted to work with nylon lines threaded into bendable polyester tubes and a brass extension. When the user feels threatened, he/she can activate a mechanism for the wearable instrument to look dangerous and occupy more space creating an invisible protective barrier. It was also required that students record a one-minute video where they tested the wearable instrument in an urban environment.

5. Readapted Materials
“The present takes up all our time - Why do you want to know about our future?” Vasco Magalhães, Arquitectos Anónimos

Example: Parametric architecture tendentiously generates complex forms that are difficult to be built. Arquitectos Anónimos with the project Homeobox (Figure 4) were using parametric processes to work with a single module (beer box) and a single connector (cable tie) in order to create a complex geometry that would also be easy to build. The beer boxes were reused and re-purposed: They were no longer for carrying bottles but became structural. Openings ceased to be a place to fit hands but became a place to attach cable ties. According to Filipe and Vasco Magalhães:

“The Growth of the homebox population was subject to specific restrictions: 1. Adaptability to the morphology and dimensions of Siza’s cube 2. Structural strength 3. Accessibility 4. A universe of generative propagation 5. Variation in growth, the script behaviour “swarm” gave a set of attractors and repressors bound to the geometry of Siza’s cube.”
Through the design of their own scripts, Arquitectos Anónimos left the computers to generate multiple design solutions and then chose one. They can be compared to a DJ who does not make music but rather chooses and edits. What interests us in this project is not so much the use of scripts but the reuse and re-purpose of simple everyday materials that make complex geometries, however easy to build.

Applied in student design studios: Concepts of Ephemeral, self-built, recycled and readapted existing materials were applied in the unit Integrated Design Making at the University of Western Australia. The unit’s brief, Jedenov (2014) was an adaptation from Kaputt’s (2009) Diagrama Aranha (Spider Diagram) and it is clear that its objective is the immediate realisation of possible architecture:

“The Integrated Design Studio will not be restricted by the conditions normally implied in Architecture. Architecture is a heavy discipline. It will prevail for a long time. One should carefully consider how its constant visible presence and eventual large volume will impact its surroundings in the long term. How it will age, how its environment will age. It is of slow execution, expensive because it needs the earth’s limited resources and usually has a large number of people involved in its construction. It is also responsible for changes in the quality of living, for better or worse. When designing architecture there are multiple variables to take into account: PROGRAM - Typology, Area/Proportions/Sizes, Functionality/Organisation, PLACE - Legislation, History, Local economy, Flora, Fauna, Materials, Geography, Social, Religion, Culture, Politics, Environment, Light, Climate, Topography, CLIENT - Ideas and preconceptions, Determination, Age, Bank account. Integrated Design Studio will not carry this weight. Our studio will look into exercises from the fringes of the discipline creating situations that can be built in the studio. Finished products of their real scale.”

“Instead of asking students to design buildings in stone, concrete, glass and wood that are never going to be built, we have recreated in class exercises where students were asked to actually build something in one week with a very low budget. We require them to not to design something, but to actually build it, not to do models but 1:1 finished products. To design something that would amplify or alter the spatial characteristics of a place and to build it, understanding what was or was not achieved.”

As a first example, Canyon in which one of the group’s students worked in a liquor store. The group went looking for alcohol consumption statistics for the city of Perth. They found how much the city consumed per week and translated this number to its equivalence of liquor cardboard boxes. With this number they collected all the necessary cardboard boxes: 850kg of them. They also developed a unique folding method on which the coloured part of the cardboard is predominant on one side. This is their module. They separated the cardboard boxes by colours and carefully layered them in a way reminiscent of geological processes. Slight variations of positions enabled them to create benches and resting surfaces. Once the project was concluded one could visualize instantly the amount of liquor consumed by the city in one week:

“We focused upon how the Antelope Canyon in Arizona fitted the atmosphere we wanted to evoke within the space. We became focused upon replicating the same horizontal strata and weathering pattern, similar to the canyon, which could invite perceptions of time/erosion and energy into the space. Being a massive structure, we decided to focus on easily attainable and recyclable material. The softness and
grooves of the layering of boxes allow areas to function as seats and provide a tactile surface for the design.”

As a second example, a group of students recycled and readapted plastic cups. Each module consists of a plastic cup and a string. These modules were arranged in a way that created a variety of topographies. Through trial and error students were able to find the exact string that allows each module to move without getting tangled. Through small air movements the cups balance and shift creating mutable topographies and kinetic reflections:

“The corridor or perhaps the tunnel, captures and directs the movement of air in effect altering the cup’s position in space and time. The action of walking through or past the cups also achieves reference to Brownian motion, the action of moving particles in a state of collision, which can be noted under a microscope. The sound of cups colliding adds to this effect. The experience of sound, light and movement, and the positioning of each unit, all of which construct the corridor simulates an immersion of limitless scale, which ties into our system.”

6. Political Conscience
Examples: The studio 18:25 produced the image Prudência em São Bento where an apparently vacant Portuguese parliament is being taken over by nature. No explanation is indicated by the authors about what is happening to the parliament, leaving the viewer to speculate on it. Is democracy over? Has power shifted to Brussels?

Kaputt! Arquitectura in their entry for the competition, House of Arts and Culture, in Beirut, Lebanon made a strong political statement: “How does one design a building that has a high chance of being bombed? What should such a House of Arts and Culture represent? To answer these questions, we agreed to pull back from any warlike imagery, which had been previously (often excellently so) represented by local architects, and chose to go the opposite route. Instead of making a resistant, defence structure, we design an extremely delicate yet organic structure. Like the Lebanese cedar tree, which is renowned for its ability to resist and revive, the structure we created is peaceful and open. It says “please
do not bomb!” And this simple gesture, we believe, could constitute a small step towards peace. Architecture for peace.”

Applied in student design studios: Following these examples, Tobias Beale (2015) an honours Independent Design student from the University of Western Australia proposes a data centre in the Western Sahara a traditionally nomadically occupied country divided by a berm that runs for 2700km know as the “Berlin Wall of the Western Sahara”. By placing this infrastructure/building exactly above the berm, the building/infrastructure is itself a political act:

“The resources offered by the data centre installation attracts an increasingly stable population on either side of the berm. Goods and services start to be exchanged between locals and the data centre employees and some exchange of goods between people dwelling on separate sides of the berm. This is easier through the intermediary of the non-place of the data centre building. The non-space of the berm is further compressed. Growing dependence on the infrastructure by the
people living on either side of the facility, ensures that a high level of security is maintained.”

“Data hardware will inevitably be eclipsed in the form envisaged in this project, the ITPAC. Global networks are also in constant flux. At the end of the lease agreement, if not already eclipsed, the data infrastructure will likely be removed leaving a figured landscape and a well-established connection between the disputed territories. The non-place has been redefined as a place of interaction and exchange.”

7. Acceptance to Work with Available Materials

Examples: In the year 2000 Kaputt! arquitectura was invited to design the show window for the art gallery Carlos Castanheira with a reduced budget of €500. They took an interest in plastic polycarbonate plates and went to purchase a few of them. As each one cost €350 they decided to do the project with a single plastic polycarbonate plate that would be folded and cut without any leftovers. Through the structural lines of the plate they ran a nylon string. This string was fixed with screws to the wall and connected to the glass of the window shop with suction cups. Once in place the piece was floating in the air (Fig. 9) and fluorescent light bulbs with a simple pink theatre filter lit up:

“The design of the pangolin’s exoskeleton permits the animal to elegantly roll itself up. This exoskeleton however, is nonetheless a rigid, resilient and protective material. The Cortiço em Palma proposal is nothing more than a folded exoskeleton. It is the absence of the body that gives it strength. The exoskeleton’s transparency gives insight to the void left by the absent form. As the shape of the missing body is unknown, a strangeness is generated by the observer who views only a translucent exoskeleton floating in an empty space.”
Kirill de Lancastre Jedenov and Filipe Alves were invited in 2012 to intervene in the Pousada de Cascais. First they visited the space and the following day had a meeting with the owner. The space, designed by Gonçalo Byrne, had a rigid symmetry with a very pronounced height. In order to break the room’s rigid symmetry Jedenov and Alves considered a tridimensional installation that would reflect the dynamism of a flock of swallows in flight at the exact moment it turns. When they met the owner they were amazed to learn that the hotel would open in one week. While they were still contemplating on what to do, the owner informed them that they wouldn’t have time to create their proposal and suggested that with one single phone call he could get as many Bordalo Pinheiro swallows as he wanted. Not fond of how the idea was becoming figurative Jedenov and Alves asked for a number of Bordalo Pinheiro swallows that they considered to be impossible to obtain as they are hand made: 600. With one phone call the owner managed to order 600 Bordalo Pinheiro swallows to be delivered in three days. With this in mind the project was designed because this was the material they had as they would never be able to find another material with such short notice. They designed a flow for the 600 swallows that would pass from one wall to another, then to the ceiling and through the skylight breaking the rigid symmetry of the room. The result is not what Jedenov and Alves wanted, it is the possible result that was well accepted by the owner and hotel clients.

**Applied in student design studios:** When this project was shown at Innsbrück Universitat, a group of students - that had one week to do a project - decided immediately to do the original three-dimensional proposal for the Pousada de Cascais. They imagined it made of light and went looking for available materials. In the university storeroom, they found 27 fluorescent lamps of different sizes. It was immediately decided that this would be the possible project with the available material (Fig. 11). Their description: “Rules for fishes: follow the fish in front of you. Maintain the speed of the fish next to you. With the rules out of the analysis, we started to do the flow.”

**CONCLUSION**

The world is rapidly shifting. It has always shifted and humans adapt to these shifts. Rapid is the novelty. As soon as we adapt to a different state the world has already moved to another
leaving us completely unprepared again. The heavy and slow discipline of Architecture has difficulty keeping up with the changes of the last decades. Architects act on issues of territory, scale, culture, politics and technology. While architects design buildings the same way as in the last century, cities are created according to the range capability of Wi-Fi networks, one country intercepts and analyses all communications made by another country and unmanned drones cross deserts in search of their victims. If this happens today, what will take place in the near future? In a finite world, fully explored, architects and designers cannot continue to work with the classical methodologies of the tabula rasa or rehabilitation of the pre-existing as it once was. It is important that students understand that there are other available fields for them to operate. Other tactics used by emerging Portuguese architects such as International Adaptable Networks, Social Conscience and a long term sustainable approach are now being applied in design studios at the University of Western Australia by Lara Camilla Pinho from blaanc borderless architecture with great success.

There is a clear connection between the number of architecture studios and the quality of architecture projects in a city/country. Places like Europe and Japan that are usually well known for high architecture standards have many architecture studios of all sizes. Places with lower architecture standards usually have less variety of practices that lead to less competition. Large architecture studios usually dominate the market. In high-density cities such as Hong Kong it is virtually impossible for an independent young architect to have a building commissioned. If they are lucky they might do interiors for a portion of one floor of a skyscraper. In Australia major commercial businesses design vast parts of the suburbs - with little or no intervention from an architect. Big architecture companies get most of the remaining commissions. Learning with the tactics developed in times of economic crisis we can empower students to be more independent through self-build and building 1/1 finished products. We can also teach them to work with what is available. This in itself could lead to a more sustainable model where materials travel less reducing the ecological footprint. Our aim is to empower students, for them to start planning to have their own studios, no matter what size they are. If we are in a position to increase the number and variety of architecture studios in Australia and Hong Kong, we are most likely also increasing the architectural quality of these places.

In the near future we will continue to test these tactics in design studios. We are also planning an Australian participation for the Lisbon Architecture Trienale 2016, where we will teach Australian students from UWA the tactics developed by Portuguese architects and they are going to apply this tactics while they operate directly in Portugal – our strategy unexpectedly went full circle. We will explore these tactics further and we will also be looking closely at the work produced in other countries affected by the European crisis.

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REFERENCES
Caldeira, P. Santos, P. and Ravara, P., 2013. DOMP, Estudo de caracterização dos arquitectos portugueses
Jedenov, K., 2014. Integrated Design – Making, Studio Brief, UWA.
Jedenov, K., 2015. Integrated Design – Making, Studio Brief, UWA.
Liquid states and concrete uncertainties

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ABSTRACT

Through the lens of a specific material, the paper advocates a risk-based methodology in design-research, teaching and practice. In search of alternative to the more immediate design protocols and diagrammatic thinking pressuring architectural education today, new ways of making are sought.

Concrete as process rather than concrete simply as a material sets an empirical endeavor in prototyping, where risk is averted by an urgency to gradually anticipate a high plausibility for failure. From active experimentation with the material (liquid to solid formations) and its properties (pressure and leakages), the curious mind is provoked cautiously to failure and is left no choice but to reinstate a ‘No Safety Factor’ approach, if creativity is to be prolonged once more. Incremental trial and errors experiments in formwork design, closely engaged with a short-lived liquid mass in space stretch at most a design process opportune to physical discoveries yet prone to uncertainties; a potent diversion to resist any predicable formations. The current (formwork) findings from a live design-research project, titled ‘New Orders (NO), in search of a new point-block diagram for Hong Kong’, manifest some of the claims raised above and further speculate from various case studies in studio teaching and practice.

NO projects a series of alternative structures for housing through a prototyping process. Nine proto-structures are developed through the conception and realization of columns cast in concrete. The series explores specific structural articulations at 1:1 scale which are further architecturally tested as speculative towers for urban living at 1:100 scale.

At 1:1 scale, new techniques of formwork design, which employ a range of materials (hard and soft) are put forward in an effort to anticipate more responsiveness to the concrete properties and to strive for more fluidity, lacking between tectonic elements currently. The point of departure for this project is the ubiquitous and rudimentary column-slab system, still dictating its way at most building scales.

By revisiting the work of the early ‘structural rationalists’ [E. Torroja, F. Candela, P.L. Nervi, H. Isler, R. Maillard, E. Dieste, et al.], NO considers the transformation of structural languages to revive an architecture for vertical living (point-block).
While these structural mavericks took reinforced concrete to the limit of what the new material could do both structurally and spatially, their pioneering work responded, for the most part, to lower building scales and to singular programs (i.e. civic, cultural, religious); all but housing. NO revives the dialogue in the context of high-density Asian living. The dialogue is being pursued with new formwork techniques that break the homogenizing influence of concrete. The overarching design-research proposition is to reassert structural design, construction procedures and material properties as the main driver for novel spatial organizations in a way that helps break from the monotony of current systems. In support of risk-taking, NO argues for design anticipation through non-linear ways of making; more specifically by concocting temporary apparatuses or falsework (in the case of concrete formwork) that refrain and swerve the Maker away from that first impulsive sketch.

INTRODUCTION

‘I am worried by what is done with new materials, or rather what is not done… Because it can flow, it seemed to me that concrete should give rise to very different articulations, more closely related to the requirements of living volumes.’ (Huber, 1971)

A material of choice in research-based experimentation has been concrete. As much prominence in [digital] fabrication has been placed on surface definition machined from sheet materials and on standardized building components, the virtues of working with volumetric materials has largely declined (Clifford, 2014). Instead, in actively engaging with liquid concrete, not only an urgency to confront live forces (such as mass and pressure) is accrued, but volumetric thinking is able once more to influence the design trajectory of a project. New forms of architecture may emerge again from the resurgence of prototyping with volumetric materials, as with reinforced concrete, a continuous medium still carrying much untapped potential.

In this regards, concrete as process rather than concrete simply as material, switches the focus instantly on the preemptive; that is the conductive uncertainty necessary to comprise all which comes before any solid formation. The insistence on designing procedures of making, and more specifically on conceiving temporary formworks or falseworks congruous with the liquid material, serves therefore as the protagonist for this essay.

FALSEWORKS: MEDUSA

A first experiment on fluidity revisits a historically pertinent column to slab archetype also known as umbrella structure or mushroom column (as found in the work of Nervi, Candela, Wright, Artigas, et al.). While performing from vertical to horizontal, the full scale prototype Medusa explores alternative materials for formwork design that are more responsive and adaptive to the casting process. Aiming at greater continuity between column and
slab, the prototype comprises of three interlocking legs demarcating a central aperture through which light diffuses internally. The overall formwork system is made of tailored geotextile legs stretched onto a timber framework. It is cast upside down to make full use of live gravitational forces and once cured, flipped back to its intended position. Locally, a constellation of cables and beads placed in tension redirects the flow, pressure and volumetric distribution of the liquid mass against the responsive formwork. The various types and magnitudes of forces exerted onto the formwork are left impressed on the surface of the concrete, amplifying the distinctive fluid property of the material. Yet, their final surface registrations are curiously read as if counter reacting to what the laws of gravity would normally dictate.

By being cast upside down, the experience of the final built prototype constantly fluctuates from solid to liquid state and demonstrates an ambiguous resistance to its otherwise affirmed belonging. The resulting effect could only be achieved by placing much attention on the conception of the formwork and on the subsequent procedure of construction rather than on the final form.

Furthermore, this research in fabrication was incrementally conceived collectively with students through teaching and the full scale prototype realized with the collaboration and support of an industry partner.

The main intention of the project is to bridge academia and practice, design and construction by meeting half-way.

That is, with students we took residency in a mass-production precast plant in Dong Guan, China and reciprocally engaged with fabricators, engineers, precast experts, tailors, steel workers, carpenters, riggers, welders, concreters and others. The realization of the project would have not been possible without mutual knowledge exchanges on site. A key pedagogical aim is to expose students to full-scale construction and to actively learn from different building trades and techniques. By being strategically located next to the Pearl River Delta (formerly known as the factory of the world), research-based practice in Hong Kong presents unique opportunities of collaborations at the onset of any design projects, with large-scale manufacturers and technologically advanced factories.

HOUSE ME TENDER

The previous experience in learning how a large precast plant operates daily provided the inside knowledge for a live Research & Development project named House me Tender.

The proposal exploits Hong Kong’s precast tradition in housing by envisaging customized modular plug-in possibilities. Reconfiguration of formwork parts from existing chain
of productions presents future residents with catalogues of precast variants. Based on needs and desires, they are able to choose independently the extent of their living spaces straight from the factory. Consequently, the implementation of mass customization through formwork procedure makes the overall identity of a residential complex singular yet heterogeneous. The ultimate social ambition for the project is to reassert the individual as the main protagonist for the making of their own living environment.

Mass customization is not a new concept and can be found in many other fields such as in product design or in the automobile industry, but as of today it rarely occurs in built architecture, especially in housing. The concept of producing variations from a type is often paired with the advancement of digital fabrication and therefore directly dependent on software communicating with machines (Smith, 2010). Because architecture relies more and more on industrialized parts to construct buildings, this new paradigm for housing seems much overdue.

Through revisiting current formwork methods, a set of possible varied outputs from a precast type could be made largely available. Steel formworks based on existing technologies are cyclically being assembled, disassembled and reassembled on the production line daily. Reconfiguring them with supplementary interchangeable parts would not necessarily compromise the efficiency of production, but will further enlarge the pool of dissimilar precast outcomes. To seek to implement mass customization in precast housing puts forward greater flexibility and adaptability over time in accommodating various types of living units for various social needs. It would also further challenge the supported tendency to segregate housing types for specific social groups (i.e. low cost vs. high end).

NEW ORDERS

The live project proposes new diagrams for point-block towers in Hong Kong. Nine concrete columns are developed through a prototyping process in formwork design at 1:1 scale.
The design-research reasserts structural design and construction procedures as the main driver for new housing speculations at 1:100 scale in an effort to break away from the uniformity of current post-slab systems. From design analysis, New Orders considers the transformation of structural languages of the work of early ‘structural rationalists’ in order to revive an architecture for vertical living.

While these structural mavericks took reinforced concrete to the limit of what the new material could do both structurally and spatially, their pioneering work responded, for the most part, to lower building scales and to singular programs (i.e. civic, cultural, religious); all but housing.

The research aims to develop new structural articulations for high-rises that are more agile in negotiating the transition from one kind of program to another within a complex. For some time now, the post-slab system has been less in service of the architect than of the developer and contractor, seeking less construction time and larger sale margins. Hong Kong’s built environment exemplifies that assertion where all living cells within a building entity have each been normalized to great heights. This neutralization in housing is facilitated by a rudimentary and fast cast-in-situ concrete frame onto which standardized precast facades and curtain walls are clipped.

Housing complexes in this context have become condensed agglomerates of sealed units around a single core, pruned for individual living. The collective qualities that once distinguished the early experiments of the Housing Authority in Hong Kong (i.e. Wah Fu and Lai Tak estates) have slowly been stripped off from buildings and at best flattened to quasi-public podia (Ottevaere, 2014). The podium-tower model, Hong Kong’s dominant duo-functional typology (commercial/residential), suggests little possibility for community living, caused by a relentless repetition of the same living cells. Indeed, integrated public spaces (i.e. courtyards, elevated streets as extensions of living spaces), outdoor living at the unit scale, shared functions, amenity spaces, public grounds and urban connectors, all of which stimulate social interaction in housing, are nowadays scarce encounters in residential projects in Hong Kong.

New Orders seeks to provide prospective residents with a range of living units types and with gradients of communal spaces that reconcile (semi-) outdoor living issues in a sub-tropical climate.

Most of the architectural investigations are being pursued through material testing and formwork prototyping. They concentrate on the physical descriptions of negative volumes for concrete casting. Some of the methods and findings are presented below:

A recurring and improved technique from the making of some of the columns involves the 3D interpolation of 2D geometries through material computation.

Global geometries are first partially translated in an assembly of various 2D edge profiles. A sheet of geotextile is then stretched onto a timber skeleton (made of planar elements) to complete the remaining 3D geometry. The method employs a simple means to fabricate complex geometries and is found more effective in deriving an optimized volume description than existing cumbersome processes concerned with the making of rigid and lost formwork (plaster copy or CNC milled positives). Once properly secured onto the timber framework, the fabric is then hardened with epoxy coating, giving it enough resistance to be cast.
More specifically, column 2 experiments with a corrugated wall as a delineator of space. The study of Eladio Dieste’s vertical ruled surfaces initiated this set of experiments. His use of conoids to amplify the surface of a wall (Ochsendorf, 2004) does not only augment the structural resistance of the overhanging arms but also demarcate the spatial and living organization of the column.

Column 4 speculates on courtyard and intra mural living by reevaluating the internal thickness change of a hollow column. Two fractal lines located at bottom and top profile are delimited from the feedback of solar analysis. The articulation of the lines corresponds to the level of solar radiation it receives. Where exposed to more heat, the lines recede inside the wall thickness to generate shade, while in areas with minimum sun exposure the lines protrude outside of the wall. The fabric technique then takes charge of efficiently materializing a series of varied channels between the two 2D profiles.

The research in column 6 begins with how to interconnect a set of sheer walls into a cohesive structure while concurrently formulating an integrated organization of mixed living spaces.

The prototyping exercise exploits the simplicity of Frei Otto’s high and low points tensile membranes, transposed here vertically. The three-dimensional surface derived from the points-set is again achieved with geotextile pressed onto a constellation of physical vectors and bounded by edge profiles. This set of protuberances not only provides greater lateral resistance to the wall structure but also directs the principal organization of the living units for the project. Each unit is laid out following two main directions, one frontal, receptive to light, and the other transversal to increase natural ventilation across the connecting walls.

The exploration for column 7 starts with Robert Maillart beamless mushroom slab structure. His elimination of beams allowed the slab and columns to perform as a monolith and continuous connection (Mivelaz, 2008). Maillart’s columns not only flare upwards to distribute the ceiling loads on larger areas but also downwards to reduce pressure on soil foundation.
Column 7 takes the doubly-flared primitive and vertically repeats it to create a compound of tall and slender elements of various periodicities and of ranging density and porosity in section. The primary aim is to reorganize a multi-storey high-rise into partial aggregations of horizontal instants, unevenly distributed across the height of a column. The formwork method for this prototype is modular. The negative balusters are comprised of rigid parts for the slabs and soft ones for the vase-shaped elements. The vase-like modules are also made with fabric stretched on planar profiles.

The idea of modularity is tested further in column 5 with the introduction of methods for mass-production and formwork reusability for repetitive casting. In making use of quasi-periodic geometry (disclosing long range vs. close range symmetry), the column employs a minimum types of concrete elements to form a field of maximum diversity.

From adjacency analyses, assembly rules are determined by sorting which edge of a tile can combine with which edges of other tiles (Ottevaere, 2009). Six formworks only are needed to create a diverse field of 41 repeated elements. They are devised as 8-part moulds in the production of the 3-dimensional modules. The CNC parts of the EPS mould are made independent to ease the (re)assembly and dismantling of the formwork at each pouring cycle.

In some instances, undercuts found in the global geometry of some of the columns poses a main challenge in the execution of formworks. Such is the case in the stacking of Hypars (double curved ruled geometry) describing the central public voids of column1. The fabrication accounts for the issue of formwork decentering found in thin shell structures with the introduction of an intermediary step in the making procedure. Rubber plugs contribute to the hybrid formwork with their ductile property to prevent any concentration...
of stresses on the concrete shells during the demoulding process.

Overall, the fabric technique, incrementally developed throughout some of this prototyping exercise is not dissimilar to an effective method invented by Philippe De L’Orme, now called stereotomy. This art of stone carving made efficient use of projective geometry by translating spatially complex solids into two-dimensional templates to guide the stonemason in the carving of a block (Evans, 1995). The method employed here also rationalizes complex solid geometries into frameworks of simple 2D profiles from which a softer material (geotextile) optimally computes the overall three-dimensional negative space for volume casting.

LINE ON FIRE

This last section on falsework puts forward new topologies generated from the description of a line moving in space. The investigation begins with the realization of three timber structures (Pinch, Sweep and Warp), focusing on timber formwork research. Learning from the work of Felix Candela on Hyperbolic Paraboloid surfaces for thin concrete shell construction (Garlock, 2008), the structures retrace how ruled geometries (generalized by a sequence of rotating lines) directly regulate procedures of formwork construction, made of straight timber elements. Sequences of changing wooden trusses capture the movement of a line to support ruled decks performing as active grounds. In doing so, the trusses are organized transversally for the Pinch, radially and tangentially for the Sweep and longitudinally for the Warp.

The results are three small-scale social programs: a library, a play area and a roadside marketplace. Located in remote mountainous landscapes (Yunnan, China), each project was designed with a strategy of maximizing the use and experience of the landscape. They were each built with students and with the help of a local timber workshop, developing construction methods for adapting highly articulated geometries to simple traditional techniques. Situated at the intersection of teaching and research, experimentation and on-site construction, complex geometry and local craftsmanship, these design-build projects embolden students with full-scale construction exposure in difficult sites through experiential learning.

Further speculations on the line as vehicle to describe volumes of revolution are considered in the prototyping of column 8 and 9. A 5-axis custom-made automated hot wire is utilized as the main research tool. By inputting specific protocols for synchronized motions (4 translations and 1 rotation), new topologies emerge defined by movement and time. These are further employed to section EPS foam blocks into part-moulds for thin shell concrete casting.

Column 8 begins with the study of Pier Luigi Nervi’s columns of varying sections found in many of his built work. Due to its plastic properties, reinforced concrete permitted Nervi to transform a column’s profile from top to bottom in order to respond to different structural demands. Informed by ‘objective static and construction consideration’, the transition from changing sections is negotiated by straight lines connecting points on the contours of each section (Nervi, 1965). The lines are then directly translated into planks for the making of the formwork. Column 8 appropriates this geometrical procedure in vertical deformation. First, various 2D sections are identified within the shaft of the column. Then, the hot wire cutter takes care of deriving the resulting ruled geometry linking the different sections. Taxonomies of EPS-plugs subsequently make up for the negative volumes in between which the concrete is then poured.
Column 9 expands on the procedure horizontally. In addition to movement, a time factor is introduced. New slab topologies arise from incremental protocols on a moving line in space. Although the project is still in production, early findings present unique slab topologies, whose forms would be difficult to preconceive through other means of digital fabrication. Being described by successions of straight lines, these intricate slabs retain an efficient and a direct link to timber formwork and full-scale construction. The EPS mould-making method also resonates with the parallel made earlier on stereotomy, although this time by operating internally in the slicing of a block.

CONCLUSION

The paper attempts to demonstrate a productive approach in conceiving architecture through education and practice by means of actively designing construction procedures, informed by material properties and principles of structures. By pursuing risk-based methodologies towards (empirical) prototyping, the design process is more anticipatory of what something might become under gravity laws, rather than being preoccupied with the material translation of a formal input.

The scalability of the presented concrete techniques at full building scales, remains an issue to be addressed in future projects. Although many of the discovered principles are sound structurally, their implementation at larger building scales would be a matter of revising first the robustness of some of formwork procedures.
REFERENCES

Press, Cambridge
Engineer, Builder, Structural Artist: 76-87. Yale University Press, New Haven
Press, London.
Mivelaz, P. 2008. Mushroom Head, Pilzdecke, pilier-champignon: metamorphoses de la dalle sans
polytechniques and universitaires romandes, Lausanne
Nervi, P.L. 1965. Aesthetics and Technology in Building. The Plastic Richness of Concrete Cast in Place: 23-
36. Harvard University Press, Cambridge, Massachusetts
Princeton Architectural Press, New York
Acadia, Chicago
Ottevaere, O. 2014. House me Tender, Total Precast Cell Systems for Mass Customized Housing in Hong
Kong and China. GSTF Journal of Engineering Technology, Vol.3 No. 1
Hoboken, John Wiley & Sons, Inc.
A certain degree of uncertainty: embracing risk in the thesis project via the ‘creative survey’

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UNCERTAINTY AND THE THESIS PROJECT

In our desire and responsibility as educators to equip our students with useful skills for their future careers in practice, we spell out very carefully the challenges that lie ahead. The effects of climate change, scarcity of resources, the marginalisation of the profession, the weight of personal debt, all stack up to present an extremely uncertain future for students graduating now, and it looks like these challenges are only set to increase in the future.

Sometimes I wonder whether this detailed explanation of how difficult their careers in architecture are going to be can be counterproductive. There is perhaps a fine line between readying students for the fight ahead and scaring them into immobility. I also can’t help but reflect that highlighting to students the skills required for future challenges, only serves to highlight the inadequacy of many conventional methods of architectural education. This paper explores one pedagogical tactic that goes some way in empowering students to cope with and embrace uncertainty, both in the design process and in their future practice.

Over the last 14 years I have taught 180 fifth and sixth year MArch students in design studio. Between 2013 and 2015 I ran Sheffield School of Architecture’s MArch course, with oversight of 225 students across the two years. I therefore have a very good understanding of trends, shifts and developments in student design projects over time and across many levels of expertise. Having also reviewed at other schools of architecture across the UK, tracked RIBA student awards, and visited many end of year exhibitions, I believe that I have a good sense of the work produced at MArch level nationally. I suggest that over the last decade, at MArch level, student design ambition and willingness to experiment and take risks has decreased. I see this evidence of playing it safe both in the outcomes and processes of design and most of all in the final year, in the thesis project. The irony is that in their final year, when, more than ever before, students should have the skills to embrace risk, they are often developing thesis projects that merely replicate existing models and do not prepare them for the challenges ahead. This paper explores the role of uncertainty in the thesis project with the aim to discover whether consciously embracing uncertainty can bring benefits both to the quality of the design research produced and also to our students’ future careers.

The method of the creative survey attempts to reinforce and valorise the “divergent” or “exploratory” phase of design research, as identified by
Plowright (2014), where a project is defined, shaped and developed through creative critical enquiry and testing. This is a resistant approach to the growing emphasis I see upon the “convergent” or “evaluative” phase of design research where value is placed upon the measuring, sorting and analysis of information. I suggest that an over-emphasis upon the convergent phase of design research can too often result in reductive thesis projects of limited scope framed by pre-existing models and that are instrumentalist rather than speculative in their attitude towards problem-solving.

UNCERTAINTY AND THE CREATIVE SURVEY

Over the past 10 years I have developed a pedagogical tool in my design studio, the creative survey. In this paper I suggest that this method can help students cope with, and indeed, welcome uncertainty into the design process and I reflect upon the problems, opportunities and consequences associated with this. Referring to interviews with past and present MArch students from my studio I will describe how this way of working has affected their attitude towards uncertainty within their education and within their ongoing careers in practice.

I will describe how, in its development, the creative survey has expanded from a single exercise at the beginning of the design process to become the crystallisation of a broader critical methodology for the production of a thesis project that we believe has wider implications on architectural practice. In the writing of this paper I have found the work of Helga Nowotny around uncertainty in science and social science, culminating in her book The Cunning of Uncertainty (Nowotny, 2016), to be very useful and much of this paper’s enquiry is developed through the lens of her theories on the subject.

INTRODUCING THE CREATIVE SURVEY

Frustrated with the limitations of existing site survey practice and the abstraction enforced by conventional modes of survey documentation, I have identified and further developed non-conventional survey techniques that engage with site differently. In my teaching I call these techniques creative surveys and since 2005 have been implementing, researching and developing the creative survey through my practice and teaching in collaboration with my students.

The conventional site survey is limited by its tendency to locate the architect-surveyor in the role of expert, observing the site as an abstract field of operation, a delimited, static and a mostly physical entity. If the conception of site were to shift closer to the reality of a changing place, conditioned through the complex intersection of multiple factors (Kahn, 2011), then the role and actions of the surveyor should change also. If the site is to be seen as a “relational construct that acquires meaning and value through situational interaction and exchange” (Burns and Kahn, 2005) then to appreciate this the architect surveyor should play the role of an active agent of interpretation” (Pearson and Shanks, 2001), closing the gap between surveyor and site. If we take the constructivist attitude that “a site exists out there in the world but acquires design meaning only through its apprehension, intellectually and experientially” (Burns and Kahn, 2005) then this active interpretation on site by the surveyor becomes fundamental in the construction of the meaning of site. The potential is there then to multiply surveyors and therefore construct multiple meanings of the one site, an opportunity to remove the survey from the province of the expert and place it into the field of collaborative enquiry.

In response to these desires for thick descriptions of site, the aim of the creative survey,
therefore, is to construct architectural knowledge, individually and collectively, of the past(s), present(s) and future(s) of site, through situated propositional performative actions. Inspired by the interdisciplinary enactments of Theatre/archaeology (Pearson and Shanks, 2001) they form relationships between the architect, site and local people by producing incorporations of site that combine “juxtapositions and interpenetrations of the historical and the contemporary, the political and the poetic, the factual and the fictional, the discursive and the sensual...their parts do not necessarily cohere. They will require work but they leave space for the imagination of the reader. The interpretive instinct of the visitor is not denied: meaning is not monopolised.” (Pearson and Shanks, 2001).

In the past, students have danced in town squares, fished into forgotten rivers, searched the city for free power, built dens and staged a crime scene and in their partiality, temporality and contingency, all these creative surveys were inherently uncertain.

**INTRODUCING UNCERTAINTY**

Nowotny identifies the lure of uncertainty, coupled with our curiosity, as the driving force of creative human endeavour (Nowotny, 2016). Uncertainty is not only present in everyday life but also is “embodied and enacted in notions of the future or in the domain of knowledge production” (Nowotny, 2016). It is impossible then, to escape uncertainty in any form of propositional design practice, especially one with a social aspect, such as architecture. However, our “craving for certainty”, Nowotny suggests (2014), masks both the presence of uncertainty and the opportunities it offers within “the open horizon of human betterment”. She identifies the desire for predictable and certain outcomes as an increasing tendency in science and in social sciences where there are “expectations to provide knowledge which is deemed adequate to mitigate specified social problems and come up with solutions to what is to be done about them”. I would suggest that this is also a growing tendency in architecture and agree with designer Bruce Mau when he says, “We won’t solve the problem just by developing the solution” (Hyde, 2012). Mau calls for a more open, inter-disciplinary and optimistic attitude to the future where creative
approaches are developed that are “compelling and exciting” and that “touch you in some way emotionally” (Hyde, 2012). This paper proposes that by engaging with uncertainty in the creative process, for example through means of the creative survey, students can discover new emotional connections between themselves and the work they do. This leads to a greater sense of personal satisfaction and achievement, but also, in the process, collaborating and communicating more successfully with others and producing work that recognises the value of serendipity, long established as a form of cunning in science’s creative process as “the unexpected finding of something one was not looking for yet whose significance one recognizes” (Nowotny, 2016).

I suggest that students should be encouraged and helped to recognise and work with uncertainty for two reasons. First, actively working with uncertainty develops skills that are incredibly useful in their future practice, namely “adaptation, anticipation, preparedness and even innovation” (Nowotny, 2016). Secondly, picking up that last skill of innovation, students who embrace uncertainty in their own work can produce design research that surprises them and their peers by being far more creative and complex than they ever imagined they could produce. This learning of how to both cope with and profit from uncertainty can be an exhilarating experience for students. Realisation of the “cunning of uncertainty”, equips students with “a complex but very coherent body of mental attitudes and intellectual behaviour which combines flair, wisdom, forethought, subtlety of mind, deception, resourcefulness, vigilance, opportunism” (Nowotny, 2016).

INTRODUCING THE INTERVIEWEES

This paper explores the relationship between the creative survey and the cunning of uncertainty through interviews with five past and present students from my design studio. All of them were, or are final year students and had been introduced to the creative survey early on in their thesis design process. Two of them have only recently, within the previous month, carried out their first creative surveys on site and are in the process of developing their thesis project, the others had completed their thesis projects, graduating between 2012 and 2015, and so were able to reflect upon their thesis project from the context of their current practice. The students interviewed via email were Kirti Durelle (KD) graduated 2012 and Timothy Waddell (TW) graduated 2013. The students interviewed and recorded in person were Matthew Pearson (MP) graduated 2015, and current Y6 MArch students Jennifer Clemence (JC) and Jonathan Day (JD). The students were chosen because, in the case of the graduates, the creative survey had become an intrinsic and continuing methodology that had fundamentally affected the development and outcomes of their thesis projects. The current students were interviewed because of the curiosity and openness with which they had just recently approached the creative survey method. The intention was to interview students who had quite clearly benefited from the creative survey technique, beyond its capacity to act merely as an alternate survey method.

THE TENSION BETWEEN RISK-TAKING AND PLAYING IT SAFE

The interviewees recognised the craving for certainty that Nowotny describes, and identified it in many arenas that had directly impacted both upon their academic work and their perception of their future in architecture. These arenas included the risk-averse construction industry, the challenges of climate change and, closer to home, the need for employment and the desire to do well in their studies. One described how, before he started his final year, he had already identified, by looking at past projects that had done well, “copyable ways of working, that ticked all the boxes” (MP, 2016) and had felt pressure to follow this more predictable route to success. However, all the students also recognised
the valuable opportunity that the academic environment offered to experiment and take risks, an opportunity not so clearly present in the world of practice. They felt the tension between these two sets of desires, to experiment and to play it safe, quite acutely, “if you focus on the market you miss the opportunity in your thesis project to experiment when you won’t have that opportunity again in practice” (JC, 2016) and “many people play it safe and produce similar programmes and similar architectural outputs but it’s important to experiment and Uni is the best opportunity” (JD, 2016). It was interesting to hear how the students also believed that the structure of the year made it difficult to experiment despite encouragement from course leaders and studio tutors to take risks with their work, “you feel the pressure in 6th year to find the project quickly so you can hit the deadlines through the year” (JC, 2016), “I felt the pressure of time and wanted to make sure I hit deadlines” (MP, 2016).

FEAR, DOUBT AND MESSINESS

I introduce the creative survey as a studio methodology in the first week of the studio and invite the students to work performatively on site within the first 2-3 weeks. Most students are expecting this because the studio has built a reputation for its creative survey work and deep immersion on site (the studio name is now Studio in Residence to reflect its close relationship to sites). However, no matter how much theory I introduce with the creative survey and how much evidence I show of impact on past projects, I find initially that most students perceive it merely as a quick and easy technique to reveal more information about the site. In fact one said very candidly “I didn’t think the creative survey had any merit at the time - I just wanted to get my head down and do my project” (MP, 2016). It is only in the action of the creative survey, in the enactment of what Judith Butler would call “a doing” (Carlson, 2004) that the full potential of the creative survey emerges through their own direct experience; “The creative survey approach embraced the process of site discovery as a design tool, rather than a preliminary fact-finding exercise meant to inform the design process later on.” (KD, 2016).

When asked how they felt when doing the creative surveys, all the students spoke of how daunting it was to be so present and active on site and how far out of their comfort zone this made them feel. It felt “like I was breaking the law!” (MP, 2016) and “It was kind of terrifying actually; equally exciting and stressful; it certainly filled me with doubt.” (KD, 2016). Although they initially felt rather nervous they quickly learned how to engage people on site in conversation, “the first day was daunting, you feel pretty self-conscious, but you learn pretty quickly how to approach people and then become more confident” (JC, 2016) and ended up enjoying themselves “the whole experience was fun, that’s the best way to describe it” (MP, 2016). They all recognised the uncertainty that the creative survey introduced into the early stages of their projects, which at first was rather unsettling, “I felt a little bit lost” (JD, 2016), “[I was] unsure as to how these actions may translate into an architectural thesis” (TW, 2016).

All of the students reflected particularly upon the uncertainty that their encounters with other people on site brought to their design research, recognising in the process “in the real world, things can become messy very quickly” (Nowotny, 2016). Jenny sought the active input of homeless people she had met on site and gave them disposable cameras to document their day - a rather chaotic process with unpredictable outcomes. The photos and insights she got back, however, were “very revealing and rather emotional” and she was surprised by the unexpected creativity demonstrated in some of the images, leading her to reflect on how the creative survey “gets rid of preconceived ideas of people” (JC, 2016).
Some of the students recognised the effect the creative surveys had on their own understanding of knowledge; how it is made, by whom and how - “the point is you are doing something you’re not an expert in for a change - that way you are taught by locals and find out how the site works from their point of view” (JD, 2016).

The participatory nature of Tim’s creative survey led him to evolve a thesis project that he defined as “a relational construct”, both in its design process and outcomes.

“As the design progressed I gradually became more comfortable with exploring the site with others, and developing a co-authored proposal. The sense of uncertainty that initially filled me with fear became sought after to aid project progression.” (TW, 2016).

This resulted in one of the bravest thesis projects I have been lucky enough to tutor - a speculative proposal that presented an ambitious formal design as the fluid product of a creative participatory process while still capturing all its inherent complexity, contradiction and compromise.

“Without creative surveys this thesis would not exist. They were the locus towards a dynamic, incremental, and living architectural process. Creative surveys provided clarity on how and where I work most effectively. I now understand that, as an architect/designer, I work best in complex and uncertain environments, where projects are developed in collaboration with local residents groups through consensus.” (TW, 2016).

These moments of learning how to work with people in co-created situations, co-producing knowledge, gives students direct experience of how they might approach, what Nowotny identifies as “the next big challenge for science”, equally a challenge in architecture - “how to bring society in...and let it take part, not only as consumers or presumed beneficiaries, but as producers of knowledge in the process of research itself” (Nowotny, 2016).

Performativity, Complexity and Uncertainty

Working creatively and performatively with site throws up lots of information in the moment that needs to be captured and reflected upon. A performative action is simultaneously active and reflexive, it is doing the thing itself while thinking about doing the thing itself, involving the sense of an audience even if that audience is the self. This immediately introduces Richard Bauman’s “consciousness of doubleness” (Carlson, 2004), requiring students to meet the complexity of these situations head-on and navigate their way through the shifting territory of subjective and objective knowledge.

“I inevitably had to relinquish control to the reality of the site – the weather, the other people who were there, the fact that perhaps my plan was not so good after all... But that was ultimately the whole point of the exercise, the tension, the confrontation between what was planned and what actually happened. I mean, this is architecture practice in a nutshell.” (KD, 2016).

Nowotny (2014) identifies a “rise of complexity in today’s world” asking “how can we cope with complexity?”. She suggests that the commonplace application of statistical and digital modelling in science reduces complexity and denies the role that uncertainty can play in the creative process of knowledge production. “Science thrives on the cusp of uncertainty” and it is only in learning to navigate the non-linear dynamics of complex open and evolving systems (Nowotny, 2014) that future researchers (and I would add to
this, designers) can explore “novel ways of seeing, intervening in and interpreting the world and pushing the boundaries of what is known further into the territory of the unknown” (Nowotny, 2016).

CERTAINTY AND UNCERTAINTY

This desire to recognise and embrace uncertainty within the thesis project is not a call for unlimited freedom and wild speculation, rather a reminder that good design and research is “simultaneously constructed from real phenomena and invented... In other words, both design and research are well-fabricated hybrids. Composed of both objective truths and personal fictions” (Salomon, 2011). The production of a thesis requires a rigorous systematic framework within which the opportunities brought by uncertainty can flourish, “Play needs firm limits, then free movement within these limits. Without firm limits there is no play” (Koolhaas and Mau, 1995).

The interviewees recognised the importance of a balance being struck between logic and intuition throughout the production of their thesis projects, “it’s also important to do the general desktop research once themes have emerged from creative survey” (JD, 2016). Once achieved, this balance lent a sense of security and freedom to push boundaries in their work, for example Matt embraced uncertainty within his project but always within a framework of certainty. He was very diligent in producing clear detailed information on context, site as existing, supporting data and research etc., to form a firm foundation for more open explorations, providing a framework that provided security for him (and his tutor!) in order to make space for experimentation elsewhere, “I found that if I modelled the context in a detailed way, then that allowed [me] to take bigger risks and do more provocative things with the site ” (MP, 2016).

Writing on how opportunities for risk-taking and innovation can be cultivated with the research design studio, David Salomon (2011) calls for the development of “experimental cultures” in architectural education, within and beyond the thesis project, through the integration of “...both rational and irrational inquiry. This new culture, logically and intuitively, collectively and individually, would use its skills to alternatively generate and evaluate new experiences, knowledge, and things directly from the material world around it.”

This “recursive process”, as he calls it, echoes the relationship between rational “day science” and intuitive “night science” recognised by biologist François Jacob (1987, cited in Nowotny, 2016,) and student Tim Waddell’s “reflexive, co-creative approach” to his design research development (2016).

CREATIVE SURVEY AS DESIGN RESEARCH METHODOLOGY

The students who benefited most from the creative survey were the ones who came to understand its potential as a design research methodology rather than it being merely an alternate method to reveal site information. Kirti Durelle structured his thesis project around self-organised sequential creative surveys on multiple sites and went so far as to say that “the creative surveys became the thesis project” forming
“a dialectical relationship where site and ideas would influence and reshape each other...understanding that the research never really ends: the finished building is part of it and it too remains open-ended to an extent.”[KD: 2016]

Tim Waddell reflects on how his learning through adopting creative surveys as a design research methodology affected his understanding of the relationship between the production of architecture and role of the architect:

“Through the adaptation of accretive surveys within the design process, I began to view architectural production; and architecture, as a ‘work in progress’, with the architect assuming varying roles throughout the design process; observer, reporter, community member, enabler, provocateur, ‘architect’, ambassador, user, and so on. These roles, acted out in real time and with real people, allowed me to engage with a complex web of social, political, and cultural contexts traditionally ignored in student projects. By engaging with these complexities, I enacted a live
working methodology, and acquired a range of reflexive design skills that are still proving invaluable.” (TW, 2016).

CASE STUDY: THE CLAMPS

To bring this section to a close it may be useful to quickly sketch the trajectory of one student’s thesis project, from initial creative survey to final proposal, in order to try and demonstrate some of the themes that have emerged in this section.

Last year, at the start of term, I asked my students to construct, in groups, survey apparatus to install on site in Sheffield. One group devised a series of ‘clamps’, a family of bespoke machined fittings to be installed around elements in the site including handrails, railings, grilles, columns and benches. Matt Pearson (2016), as quoted earlier in this paper, didn’t expect to get much from this exercise but, despite this, took it seriously, if only to get some nice images for his portfolio. He certainly wasn’t expecting how the creative survey would disrupt his carefully prepared strategies for the year - it “massively opened up the project” and introduced uncertainty right into the heart of the thesis. On a simple level he surprised himself by enjoying and learning from the creative interplay between the group and also found the information that came back about site to be much more useful and interesting than he expected “loads of conversations, a more rounded idea of what’s happening [on site] right now”. Once installed, the clamps became triggers for events and taking time to install and operate the clamps meant the group were on site for many days. This afforded them the chance to create a thick description of site, capturing individual and collective readings, some generated themselves, some drawn from others, all hovering somewhere between fact and fiction.

For Matt this creative survey developed an unexpected and powerful bond between himself and the site. This was the “first time I had ever made things at 1:1” and “it was the first thing [of mine] that has ever got built and put in the built environment”. This initial pride in construction was tested very quickly as the clamps were left on site and disappeared through vandalism, demolition, destruction and decay. This was a very successful creative survey with the group able to interpret the work in many ways that led to a full range of diverse projects. The clamps affected Matt’s thesis project at many levels - directly informing the production, form and programme of his thesis. Before the creative survey he had every intention of designing a manufacturing plant, after the creative survey his thesis, The Heart of the Machine, became an explicit process of design research, continuing to use creative surveys on site to explore the interdisciplinary production of architecture through the integration of art and engineering. He also enjoyed the year a lot more than he expected because the process of design research prompted by the creative survey “allowed me to sink my teeth into something which I didn’t know the answer to” and the realisation that “to do really well I needed to not know the answer”. He now believes that without the early injection of uncertainty that the creative survey gave him he would have followed the predictable model he had identified for success, probably have done well, but would have been bored in the process. He was able to trace a direct lineage from the clamps to the “the best part of the design at the end, the most interesting parts of the drawings” and felt that “the most provocative parts of the project came from this early work”.

Matt is now running his own practice and still using the creative survey techniques he learned during his thesis year to embrace uncertainty. He reflects that his thesis taught him the benefits of not always being in control, “to let things go” and that “when I was the most uncertain about things I was most creative” (MP, 2016).
MEETING THE FUTURE WITH A CERTAIN DEGREE OF UNCERTAINTY

The pressure on the thesis project is enormous

“Somehow, it must reconcile personal exploration with pedagogical agendas, combine the specific requirements of a project with a more general quest for knowledge, and fulfil the desire for invention with the need for professional competency—all the while advancing disciplinary knowledge.” (Salomon, 2011).

The pressures facing future architects are even more daunting. In his book Future Practice (2012), in the face of the crisis looming over architecture, Rory Hyde interviews many practitioners, innovators and designers to gain insight into the future roles of the architect. These include “fundamental interpreter[s] of an extraordinarily dynamic reality”, “facilitators of change among large groups of people”, “urban activist”, “community enabler” and “civic entrepreneur” - a dazzling array of possibilities for graduates, but
all these roles are still very much evolving, with no tried and tested models for success to follow anymore.

Embracing the creative possibilities of uncertainty is no magic bullet that will enable students to shape, define and fulfil these roles. However, having spoken to students and recent graduates, I believe that the cultivation of a positive attitude towards uncertainty can certainly help them meet the future with optimism and resourcefulness, “you are drawn by curiosity, you have a sense of direction, but you do not know the outcome” (Nowotny, 2014).

It’s perhaps illuminating that none of the graduates I interviewed have gone into full-time employment in conventional practice. Two of them are combining practice with on-going post-graduate studies and one has set up his own practice in temporary event architecture. Along with the current students interviewed, they were all doubtful of the opportunities available in conventional practice for experimentation and embracing uncertainty “uncertainty is rarely formally acknowledged in practice (although it certainly exists) – because architecture tends to portray itself as capable of ironing out the unknown” (KD,2016).

In conclusion, this paper attempts to show how the creative survey can help to embed “a certain degree of uncertainty” (JD, 2016) into the design research process, thus building a strong emotional and intellectual relationship between the designer and their work that is robust enough to cope with complexity and thrive on collaboration with others.

“Uncertainty is always there. [The creative survey] helped me start accepting plurality. This is a learning curve that did not stop with university, I still experience it today and it is quite liberating as a designer to embrace it rather than ignore it. [It’s] about accepting to give up a little control, to let the world interfere or contest whatever it is you decide to put out there. It is humbling really, and I find it is a really important part of being a designer.” (KD, 2016).

REFERENCES
INTERVIEWS REFERENCED IN TEXT:

I will introduce a branch of social learning theory in which learning is viewed, not merely as the acquisition of information and skills, but primarily as our changing ability to participate in the world. This entails not only a change in a person’s knowledge, but a transformation of their identity. Relevant participation happens at two levels. First it happens in communities of practice where we develop specific forms of competence. Second it happens in relation to broader landscapes of practice. This includes many communities and practices in which we cannot claim membership or competence, but about which we can claim some degree of knowledgeability that informs our participation.

‘In the complex world of the 21st century, the interplay of these two forms of participation becomes central to professionalism’

In the complex world of the 21st century, the interplay of these two forms of participation becomes central to professionalism. For a traditional school, the danger of ignoring participation is to view competence as a degree and knowledgeability as information. For forward-looking professional educators, social learning theory suggests approaches that go beyond degrees and information to focus on the formation of a robust professional identity.
Take the red pill: a journey into the rabbit hole of teaching informed research

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ABSTRACT

In one of the more well-known scenes in the film The Matrix the character Neo has to make a decision. He takes either a blue pill to return to the relative security of what he knows, or he takes a red pill to go on a journey into the depths of the unknown.

Griffiths (2004) identifies four models of research-teaching dialogue: research-led, research-orientated, research-informed and research-based. This paper focuses on the latter, and argues that this approach is most aligned with the creative and divergent processes of design studio learning. In a discussion that links the themes of participation and production, studio teaching and its associated creative processes are explored as the generator of research. Arguably the term research-informed teaching implies that research leads teaching, and therefore the approach described in this paper is made distinct by subverting the traditional term in favour of teaching informed research.

Central to the teaching-informed research approach are studio projects. They are the essential substance of the research methodology, and become the research data for analysis. This paper makes reference to two projects by the author that have adopted the teaching-informed research method in the design studio – one undergraduate and one postgraduate – which have led to award-winning and international publications. Discussions about methodology and outcomes identify some significant principles to consider and lessons learnt when designing teaching-informed research projects, which are evaluated in depth. For example, a common thread linking both projects was constructing a brief for the students to explore contemporary issues in building-types that are currently facing contentious challenges. Also, in a divergent process – which lies at the essence of the design project – outcomes are unknowable, and the researcher must embrace and account for the fact that the project trajectories are unpredictable and unexpected. The morality of students conducting research for academics is also discussed; it is argued that the pedagogic integrity of each student’s project is of primary significance, but that the value of the research outcomes often lies in comparative analysis of the collective body of work produced in the studio.

This paper will demonstrate that when structured in an appropriate way, such a journey into an unknown rabbit warren of unanticipated twists and
turns, which is an inherent characteristic of this approach to the relationship between teaching and research, can result in rich outcomes. It also argues it is an approach most suited to the creative environment of the design studio.

INTRODUCTION

There is a complex, and often uneasy relationship between teaching and research in higher education. This is frequently expressed as a tension between where academics’ priorities should lie. For example, there is evidence to suggest that national research audits can isolate research from teaching (Jenkins et al. 2003), at both institutional and individual levels (DBIS, 2015). It has also been argued that there is no simple functional relationship between quality of research and quality of teaching at a programme level, where teaching and research are often organised separately with limited thought given to how they might be linked (Jenkins, 2004).

What are the ways to unite teaching and research in Architecture programmes? The general view of the relationship between research and teaching is that the latter benefits through curriculum content being informed by research – even if it is conducted independently of the teaching – thus ensuring that content is progressive. Whilst this position is not necessarily being questioned here, Griffiths (2004) argues that research and teaching can relate to one another in a variety of ways – often influenced by the discipline context and field of inquiry – and the above scenario covers but one.

Architecture programmes, and indeed other creative disciplines, have been far from exemplary at exploring relationships between research and teaching, and identifying ways in which they can create a symbiotic dialogue. This is both rather ironic and a tragic loss. Research and innovation are fundamental parts of studio design processes, but opportunities are being missed to capture these and formalise them as research outputs, which can be presented at conferences, published and returned to the Research Excellence Framework (REF). Furthermore, publications about project work produced in studios often focus on the projects themselves, as opposed to deeper meanings signified by the work in wider contexts of challenging research problems. This paper evaluates two case studies that demonstrate potential ways to integrate design studio teaching into research projects as a central part of the methodology, leading to publishable outputs beyond the field of architectural education.

Much has been written about the relationship – the nexus, as it is often called – between teaching and research in higher education (Brew and Boud, 1995; Hattie and Marsh, 1996; Robertson and Bond, 2001; Hattie and Marsh, 2004; Jenkins et al., 2003; Jenkins, 2004). There are conflicting views on whether the relationship has a positive, neutral or detrimental impact on the quality of students’ learning experience. This paper posits a radical idea: whilst some argue that staff research is an irrelevance or even an obstacle to improving teaching quality, can teaching and research be conjoined in ways that enrich the learning experience?

DEFINING TEACHING INFORMED RESEARCH (TIR)

Griffiths (2004) has identified four models of research-teaching dialogue: research-led, research-orientated, research-informed and research-based. This paper focuses on research-based teaching which is defined as being, “designed around inquiry-based activities, rather than on the acquisition of subject content” and where, “the scope for two-way interactions between research and teaching is deliberately exploited” (ibid., p.722).
The argument being put forward here is that this approach is the one most aligned with the creative and divergent processes of the design studio.

Arguably the term research-informed teaching (RIT) implies that research comes before teaching, so as to inform content and ensure the curriculum is at the forefront of knowledge – a popular perception of the research-teaching nexus. However, in the methods described below it is studio teaching and the design processes associated with it that lead the research, and which dictate the paths that it follows. Therefore the approach is made distinct by subverting the traditional term in favour of teaching-informed research (TIR).

Central to TIR in Architecture are studio projects. Every year in every programme a wealth of creative and inspiring project work is produced. Often these projects challenge and explore contemporary problems and issues, and propose a diverse range of innovative solutions. However more often than not, after the End of Year Show these projects are catalogued and archived, and become nothing more.

In TIR these design projects provide material for research. Whilst the students will conduct their own investigations as an integral part of their conceptual thinking and design development, this is independent of the TIR processes that follow the projects’ completion. They provide the medium for analysis and evaluation against wider concepts and issues, and it is here that the main TIR processes lie. Put another way, the students’ projects are the research data. The following two case studies describe experiences of the approach, and are followed by discussion around the outcomes and lessons learnt about adopting this method of uniting teaching with research.

▲ Figure 1 Section and axonometric. The changing permeability of this dynamic structure expresses increasing accessibility to the books within, which in turn is representative of the evolving democracy of knowledge. By Sarah Aziz
CASE STUDY ONE – THE BOOK REPOSITORY PROJECT

In November 2013 a project was devised for NQF Level Six Architecture students to design a Book Repository. The brief was for the final project of an undergraduate course at a United Kingdom university – a 20-week design module. It was one of five different projects offered to the cohort of 52 students, and they were asked to choose which project they wished to work on, subject to an appropriate balance of numbers within each tutorial group. Following a democratic selection and allocation process the Book Repository project group was composed of 11 students.

An aim of the project was for creative designers who have grown up on this side of the digital revolution to explore the role of books, and of the buildings in which they are housed. The term library was deliberately avoided to encourage students to approach the project without prejudice to a particular tradition or typology. They were asked to consider: the nature of the book as an individual object, the book as a collection, the relationship between the reader and their book, and the nature of research (or searching). A site was suggested, although a number of students identified their own site during the course of the design process.

Following their completion it was clear that a number of the projects addressed a variety of issues facing contemporary library design and the role of library buildings in society. For example, despite being designed by so-called digital natives, physical books were highly significant in every project; recent research in the US (Gregory and Cox, 2015) has shown a significant – and unexpected – preference in students for books over digital media for the majority of different reading needs. However whilst real books were always present, in the majority of the students’ projects they were an expression of a larger concept as much as for reading – such as their cultural symbolism, for example. In fact spatial explorations around the activity of reading were notably limited. Several projects explored the wider and more complex roles libraries play as an important civic space and place of social interchange within the public realm. As such, these projects reflected somewhat surprising research which revealed that the majority of library visitors do not go there to borrow or return books (Aabo and Audunson, 2012). It has been argued that libraries are undergoing a renaissance (Hvenegaard Rasmussen and Jochumsen, 2009) as this traditional building type is re-invented for contemporary and future cultural exchange, and it is this re-imagination that the students’ projects explored in depth.

During the summer, after the projects were completed, a research paper was written about the changing roles of physical books and library spaces, discussing their place in the civic realm in the context of increasing digitisation and cultural diversity (Smith, 2014). The discourse was structured around the students’ projects as the central narrative thread, with issues they illustrated referenced to existing research on contemporary library design identified by the literature review. A key aspect of the overall body of work the students produced was its sheer diversity; the projects ranged from a place for storytelling to a place for writing, a third place, a meteorological observatory, a book museum and an archive. Such a multiplicity of responses highlights an intrinsic quality of the TIR approach. As a divergent process, design projects evolve in a wide variety of trajectories. For the researcher – like Neo taking the red pill in The Matrix – what lies ahead is unknowable. However, this turned out to be a very positive quality, as the paper was able to illustrate a variety of different key themes and issues. Had all the projects been very similar, that discussion would have been much less rich. This demonstrates how the inherently divergent nature of studio design projects is a strength in the TIR method.
An interesting aspect of the paper was that the tutor had no ambition to create a research output when setting the brief. That idea came after the project submissions when, reflecting back on the body of work that had been created by the students, its pertinence to contemporary issues in library design became clear to the tutor. As Schön (1983) highlights, design is not simply a matter of solving problems but also of finding out what the problems actually are. As opposed to submitting the paper to a journal about architectural education, it was submitted to *New Library World* – an established practitioner journal specialising on the changing role of the library and the impact external factors have on its future role and development. It went on to win Outstanding Paper in the 2015 Emerald Literati Awards, and led to the author being invited to write a book chapter on the future of libraries in the digital era, which also utilised student projects in the narrative (Smith, 2016). This clearly demonstrates the esteem which research based around students’ project work can achieve.

**CASE STUDY TWO – THE TERRACED HOUSING PROJECT**

New housing design faces a raft of challenges, at the forefront of which is a triumvirate of interrelated needs: to make dwellings more spacious, more affordable and less damaging to the environment. Each of these is important in their own right, but are they reconcilable? Conventional thinking suggests larger dwellings cost more, as does increasing their environmental sustainability, so consequently they become less affordable.

In March 2015 Architecture students studying the NQF Level 7-1 MArch programme at the same university were set a project to design housing for sites in Liverpool. The module lasted for six weeks during the second semester. Students were asked to select one of three typical UK housing types – an urban block, terraced, or detached/semi-detached – again subject to an appropriate balance of numbers within each tutorial group. Following another democratic allocation process the Terraced Housing project group was composed of 14 students. They were given a site in the Georgian quarter of Liverpool, not far from the city centre, and were challenged to explore the potential of the terrace typology for housing suited to contemporary forms of living, and which examined the interrelated priorities of space, affordability and environmental sustainability.
In the summer following submission of the projects, when the pressures of teaching and assessment had subsided, a comparative analysis of the projects enabled common themes and design strategies to be identified. For example, rather than just considering space standards quantitatively, numerous students explored it as a qualitative concept, which led to thinking beyond conventional dwelling spaces and questioning what modern patterns of living actually demand.

Some commonalities emerged, such as providing dedicated spaces to enable adult offspring (unable to afford their own dwelling) or elderly relatives to live as part of an extended family. As such, the family unit became a plastic concept which the students perceived as flexing and changing significantly over time. Some students proposed multiple living rooms so that occupants could relax in different ways at the same time – suggesting the notion of the whole family gathering around one television is an outdated one. Other projects proposed dwellings incorporating sliding or folding screens so that rooms could be easily reconfigured throughout the day – subdivided when different activities had conflicting needs and then recombined to create an open plan. The RIBA (2011) have argued for more research into what constitutes adequate space to suit contemporary living patterns; taken collectively these projects make some suggestions toward that understanding. Lack of natural light is a significant cause of dissatisfaction with new housing in the UK (Ipsos MORI, 2013); a number of projects addressed this, and in some instances courtyards or skylights and light wells were included as well as large windows.

In the first instance the project work was presented by the tutor at an international conference on housing, which showed the students’ work at a formative stage partway through the module. The author was invited to develop that initial paper into a book chapter, discussing the apparently conflicting issues of space, affordability and environmental sustainability in new housing in the UK, and arguing that by using advances in each separate area to mutual advantage it is possible to reconcile them (Smith, 2015). Whereas the Book Repository paper used the students’ projects as the central thread of the narrative running throughout, here the projects were discussed in one section within the chapter, using them to illustrate potential solutions to the numerous challenges that currently face new-build housing across the UK, and highlight potential trends and new ideas.
A fundamental quality common to the Book Repository and Terraced Housing projects was that as theoretical constructs the students were permitted a high degree of intellectual and creative freedom. Consequently their designs could push boundaries in exploring what libraries and housing could be. Doevendans et al. (2002) discuss three types of research: questioning-prescriptive, questioning-descriptive and research of the imagination; TIR clearly lies in the latter category. This is a highly positive quality to using studio design projects as research methodology – they can explore deeply hypothetical concepts.

Griffiths (2004) argues that research in applied fields – common to built environment subjects, including architecture – is about bringing new approaches to intractable problems and conflicts in the field, and not towards knowledge and understanding for their own sake. The implication of this for the TIR approach is that studio projects must align with such problems and conflicts. Another commonality between the Book Repository and Terraced Housing projects was a brief to explore issues in building types that are currently facing contentious challenges. Therefore, to adopt the TIR approach project briefs should not be esoteric or abstract, or generate self-fulfilling prophecies, but respond to – and be interrogated against – challenges in real-world scenarios. Writing briefs that align with contemporary problems and conflicts also strengthens the potential impact of the research, and creates wider scope for dissemination in discipline specific journals as well as those in the field of architectural design and education. Setting briefs that challenge real-world problems may be disconcerting for some teachers, as it might be thought that reality could inhibit creativity in the design process. This suggests that such projects are more suited to cohorts in higher levels, as they are better able to reconcile creative exploration within imposed parameters.
One of the key aspects that makes TIR distinct from other approaches to the research-teaching nexus is the sequencing of the project work within the research methodology. In TIR the projects take place immediately after the research question – the brief – is set. All other stages – including the literature review and analysis – follow because these are all directed by how the project work evolves, and where it leads to.

The case studies described above both followed similar sequences in terms of research process. Preliminary research was conducted to establish the context for the design brief – a standard part of setting any project. The brief was then issued to the students and the projects followed the normal journey of development for the duration of the module. Once submitted the overall body of project work was comparatively analysed to identify themes and trends. Next a literature review was conducted by the tutor to facilitate a deeper level of understanding of particularities raised by the projects. This review identified existing research about salient issues in the field of inquiry to contextualise the projects; in both case studies this covered critical issues in design, theory and policy pertaining to the building type specified by the brief.

The research output was then written using the projects to illustrate issues, drawing on the literature review to validate these. The Terrace Housing project differed slightly because the conference where the work was presented at a formative stage took place whilst the projects were running; therefore the tutor conducted the initial literature review in parallel with the projects, which had the benefit of informing the studio work as it progressed. The comparative analysis of the projects then took place following their submission, and a further literature review was undertaken before the chapter was completed.

Because the majority of the research processes in TIR usually take place after the students’ project work is completed, a potential shortcoming is that the research cannot feed into – and therefore inform – those projects. It is often argued that the benefit of research-informed teaching lies in its enhancement of curriculum content, thereby deepening students’ learning. However, if the project brief is refined in response to the TIR outcomes, then they become part of the foundations for subsequent cohorts to progress their projects from. This creates a developmental cycle to the TIR method in which each cohort can spring from the previous one. However, this does require continuity – as opposed to reinvention – of project briefs from year to year.

Although a number of students designing Terraced Housing explored increasing affordability through both advanced housing manufacture and reducing utility bills, a shortcoming was that there was no robust method for these strategies to be costed. This highlights the need for an appropriate evaluative framework through which to critically appraise the projects. In the case of the Book Repository this was achieved through the literature review, which followed completion of the projects when the idea for a paper first came about. Existing research on issues raised by the students’ work was explored, and the validity of the projects in the context of those issues then established.

Questions may be raised over the ethics of students’ work being used as part of tutors’ research. Is it appropriate that projects produced by students are subsequently used as material for staff conference presentations and publications? The students’ projects are being produced anyway, but what are the implications if they are then used as material for research?
When briefs are being written, it should go without saying that the primary objective is alignment with the module’s Learning Outcomes and any validation Attributes or Criteria that are mapped to it. Then the pedagogic depth and creative potential of the brief should be established, ensuring that strong students will be sufficiently challenged whilst those less capable have sufficiently defined parameters to work within. The relationship to a particular tutor’s research field should only then be drawn. Put simply, the learning experiences of the project precede any consideration of a research idea. Equally, the students’ exploration and final resolution of their project must be the primary focus and outcome; should their work diverge from any preconceived research objective this must be embraced and encouraged. In fact – as demonstrated above – the more diverse the projects produced, the more expansive the comparative analysis in the context of problems and conflicts will be.

If there is no increased demand placed on students beyond completing project work in accordance with the requirements of the module, arguably they benefit from having their work included in research outputs. Whether an international conference presentation or peer-reviewed journal publication, these can be included on students’ CVs, blogs and websites, thus providing means to promote their design work. By following these principles the TIR method will not fall foul of accusations of students doing a tutor’s research for their behalf. Another risk may lie in a belief by students that they have been set a particular project to satisfy the idiosyncratic research interests of their tutor. However, if students select which project they design in a module – as in both the case studies discussed above – should any brief not appeal to them then they simply avoid proposing it as one of their preferred options.

It should also be self-evident that students’ permission must be sought before publishing their work, and that they should be acknowledged in presentations and publications. Interestingly, the author has never been denied permission to use students’ project work in a research publication, even by students who have graduated and therefore are not subject to any influence of the student-tutor power dynamic. In fact, some have commented on the interest they have in seeing the tutor’s interpretation of their work when it is discussed in a wider context of the research question.

CONCLUSIONS

Every year in every Architecture programme a wealth of creative, innovative and inspiring project work is produced. Should more of this be captured in research outputs which extend beyond publications on architectural education? There is much debate over the relationship between teaching and research, and how they impact on each other; that relationship can be significantly affected by the pedagogic methods of a programme (Robertson and Bond, 2001). As Brew and Boud (1995) highlight, the nature and quality of the co-relationship between teaching and research will have significant impact on the degree of productive symbiosis. Arguably studio teaching – with inquiry-based learning and one-to-one tutorials – is highly suited to fostering close links between the two, and studio projects have much to contribute to discourse on a wide range of contemporary problems.

The experience taken from running the two TIR projects described above has highlighted some key issues to consider when adopting a similar approach. Firstly, project briefs should be set to explore contemporary problems and conflicts in building types, or the equivalent, which are currently facing contentious challenges. This creates a relevant field for the research to contribute to. Secondly, the majority of the literature review and all of
the analysis generally follows completion of the project work by the students, to explore in more depth particularities revealed by the work.

Finally, there needs to be an appropriate evaluative framework for the project work – the research data. For example, this could be comparative analysis, contextualised against issues relating to theory, design or policy in the field of inquiry as identified through the literature review. However, where that field extends beyond the tutor-researcher’s expertise, such as detailed cost appraisals or the appropriation of new technologies, then collaborations may need to be sought in order to robustly appraise the project work. Interestingly, in debate over the relationship between teaching and research there are very few arguments that teaching effectiveness makes for better research – a causal link is, almost without exception, sought the other way round (Brew and Boud, 1995; Hattie and Marsh, 1996). In sharp contrast the TIR approach, in which research emerges from the outcomes of teaching, creates a very persuasive case for placing excellence in studio teaching at the epicentre of creating good research. Furthermore, when a cyclical developmental process is created year on year, research findings and outputs from TIR can inform and enrich the learning of subsequent cohorts.

Like research, learning is also about formulating knowledge. In the approaches described in the case studies, research develops from the students’ project work, which is the product of the design process. Although beyond the scope of this paper, there is a strong case to be made for research outputs arising from of the creative processes that students engage with during the development of their projects, which would equally fall under the conception proposed here of research being informed by teaching. Either way, when teaching leads research the path will be an unknown rabbit warren of unanticipated twists and turns. However, as an inherent characteristic of the TIR methodology this can result in rich outcomes that relate studio teaching to much wider contexts, and lead studio project work into diverse fields of research.

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REFERENCES

Department for Business Innovation & Skills (DBI&S), 2015. Fulfilling our potential: teaching excellence, social mobility and student choice. London: HMSO.


Royal Institute of British Architects, 2011. The case for space: the size of England’s new homes. London: RIBA.


ABSTRACT

Instagram, the online mobile photo-sharing social networking service, appeals to architects and architecture schools because of its emphasis on high-impact visual images. Architects and students frequently post images of their work, from in-process drawings and models to full-scale buildings, providing unprecedented public access to the design process. From the perspective of an accredited architectural school, we argue that Instagram has rich potential to connect to other architecture schools, expose student work to a global audience, and reach out to donors in new ways. In general, we note Instagram’s power to enhance the profile of the profession, nationally and internationally, through what we describe as the academic “selfie”—a mode of exposing architecture school culture via Instagram.

THE RISE OF INSTAGRAM

Instagram, the online mobile photo-sharing social networking service founded in 2010, has a particular appeal to architects and architecture schools because of its emphasis on high-impact visual images. Architects and students frequently post photographs of their work from in-process drawings and models to full-scale buildings, providing unprecedented public access to the design process (the estimated number of Instagram users is now 300 million, http://techcrunch.com/2014/12/10/not-a-fad/). For example, in its most predictable usage by architects, the Instagram account of high-profile firms like Skidmore Owings and Merrill (SOM) showcases their best projects in perfect lighting conditions or in use by happy clients. This image of the firm’s Cathedral of Christ the Light in Oakland, California, for example, shows the church glowing “like a lantern”. For those of us old enough to remember the power of magazines such as Progressive Architecture, these photos recall the marketing oomph of a good centerfold in that glossy and influential magazine. In this guise, Instagram is truly what one architectural critic has called “a more perfect version of everyday life.” The non-architectural equivalents would be the gorgeous meal, the perfect outfit, the beautiful child, the flawless flower petal – Instagram is full of such idealized images.

According to SOM website, the firm has recently won a social media award from the New York chapter of the Society for Marketing Professional Services (SMPS-NY). The organization’s 2015 Marketing Communications Awards program recognizes the firm’s Instagram account, @skidmoreowingsmerrill, in its social media category.

OMA New York takes the opposite approach, posting less staged/contrived pics such as construction photos of its Faena Hotel at Miami Beach. These
are anything but idealized and are instead sloppy, messy, non-precious, etc. Such images show the making of architecture, rather than its final product. Both product- and process-oriented views, of course, are highly privileged (what we mean by this is that the real view is actually accessible to very few people).

The list of architecture firms on Instagram is quite long, including other high-profile firms like Herzog & De Meuron, NBBJ, Snøhetta, Olson Kundig, Shop Architects, and Zaha Hadid. Each of these firms engages Instagram as a strong, visually-based platform to showcase its finished work, office candids, and general inspiration. Instagram provides them with a virtual space to join in conversations with other professionals, and architecture lovers worldwide through bold visual messaging.

For those of you unfamiliar with Instagram, it is important to point out that Instagram images, which are the focus of every account, are accompanied by short captions and then followed by a long list of hashtags: key words connected by # symbols that allow viewers to search out particular interests. Social media specialists think of hashtags as an online filing system. Clicking on a hashtag on Instagram takes you to all the images that used that hashtag.

Obviously, hashtags allow for a wide exposure of images by reaching out to diverse users. They can be general like #architecture, #design, #visualization, #art, or more specific acting as a sort of trademark an account. Creating a new hashtag for a certain project, content, or account can offer audiences a way to broadcast the images relating to that
project, group, or account. Hashtags also encourage audience participation, thus serve to create a dialog about a given topic and are considered the main driver behind connecting users who might not be following the account. One of the interesting trends as well is “re-gram” or “re-post”, where users can re-publish an image from an account they are following, and if their followers see it, they might end up following the account.

The interactive aspect of Instagram is that viewers can express approval of images by clicking on a tiny outlined heart below each image, which shows as a “like”. Additionally, viewers subscribe and “follow” particular accounts, receiving instantaneous images on their smart phones and tablets. Some viewers write comments, which are most often in a casual, nearly spoken tone – and many are emotionally charged. Remarkably few are vulgar or offensive and there is no mechanism for “disliking” an image.

We illustrate with a typical example. In the case of Norway-based Todd Saunders’ image of his studio on Fogo Island, 288 viewers liked the image and a viewer named “downsworks” added: “love, love, love”. Saunders’ hashtags, a modest list, include his own name, the name of his office, the place, and the client. Saunders has 10,000 Instagram followers. Similarly, the Mexico City-based architecture firm Rojkind Arquitectos has about 14,000 Instagram followers. The account also uses a short list of hashtags, sometimes only one or two, including the project name, or describing the action taking place in the picture (for example, staff members meeting or sketching). What is also interesting about this account is that it posts pictures of work by other architects, including a project by BIG, and a presentation by Sou Fujimoto at the World Architecture Festival in Singapore in 2015.

From the perspective of architectural education, the subject of our conference, Instagram is a growing and hugely useful database of student work and school information from around the world. On Instagram we see the studios and studio work of other schools and they see ours. This image posted by Columbia University (figure 5) for example, posted thirteen weeks previously, is typical, showing the Ivy League school’s architecture studio: tables, laptops, glue, Perrier, coffee, half-completed models, lots of backs of students (a particularly irksome characteristic of architecture school photos). It is the educational equivalent to the OMA construction image, a spontaneous, backstage view of how architecture gets made.

More than 60 school of architecture across North America run active Instagram accounts. The popularity Instagram is gaining among architecture schools raises questions about the benefits to architectural education of engaging in social media platforms. We believe that Instagram offers a mode of exposure that goes beyond conventional studio life, connecting with other schools, with architectural firms, and with university alumni (especially those who are potential donors).

@MCGILL_ARCHITECTURE

At McGill University’s School of Architecture in Montreal, we have firsthand experience of Instagram. The two of us, Bassem Eid Mohamed (then a postdoc fellow and now an Assistant Professor in Abu Dhabi) and I (then the school director and now a happy sabbaticant) started a school account in November 2014: @mcgill_architecture. Basem, already familiar with Instagram, suggested that it would be good PR for the school; Annmarie was a complete novice. Our basic models were the popular accounts of two American schools: Columbia University (@columbiagsapp) in New York and Sci-Arc (@sciarcinside) in Los Angeles. The Bartlett also has a very active and interesting site, @bartlettarchucl, to which we have often looked for inspiration. It has nearly 5500 followers with only 258 posts.
To make a long story short, our site has grown quickly in the last fourteen months and we now have over 2100 followers (note: our school has 300 students). Our 540 or so postings have included student work, faculty publications, university events, student travel, convocation, and shots of daily life in the Macdonald-Harrington Building, the heritage structure we share with McGill’s School of Urban Planning. We follow 15 other schools and about 45 other schools follow us. Note we do not follow any of our students’ accounts (though Basem and Annmarie follow many students from our personal accounts, an interesting triangulation and rich source for ideas).

After about 6-8 months, our team grew to four members and we try to post images daily (or at least seven per week). Basem and Annmarie were joined by Howard Davies, a popular adjunct professor and Montreal architect with an extraordinarily close relationship with students; and more recently Manon Paquet, a Masters student. In general Annmarie and Manon post the images; Basem, now headquartered in Abu Dhabi, provides constant advice and often enriches our list of hashtags. Howard is our hunter/gatherer, always out getting us great images. Annmarie writes most captions and edits all of them for uniformity. Captions are in present tense and are careful to avoid any value judgments (ie, we never say “this excellent project”, “this beautiful model”). We believe this broad representation and neutral positioning encourages students to send us their work, building an atmosphere of trust.

We tag each of our images to #mcgill_architecture, a hashtag that acts as a trademark for all the content of our account. This hashtag is also used by many of the students to share their work with Instagram users via their personal accounts, and also global users who now search with this hashtag. We also use #mcgill and #mcgillu to reach out to the
larger McGill community. We saw the power of hashtag outreach after only a couple of weeks running the account. Starting up mcgill_architecture in time for final studio reviews in November 2014 meant we had bountiful material to post immediately.

We tend to err on the side of caution in our choice of images. Typically, we try to select images that express a strong statement with regard to design, modelling, or the depiction of school facilities. We post representations of both traditional and digital media. We also post many images of events, studio reviews, and student gatherings, as a way of exposing the dynamic social climate in the school.

Through this collegial experience, we have come to appreciate two aspects of Instagram that show our work way beyond any website or school catalogue might do. Firstly, the power of non-conventional hashtags to connect our images to a huge audience searching for specific types of work. For example, including the hashtag #inflatables on our image of PhD student Susane Havelka’s prototype dome for the Arctic meant that viewers looking for inflatable housing could find it. This, in fact, brought us more followers, showing the aspect of design/build practice within the school’s programs.

And excitingly, our images are often reposted on sites with much higher numbers of followers, exposing our school and work to a whole new audience. This is extraordinary for students of architecture. We offer three examples in this regard. In December 2014, when we had just started the account, U3 student Alex Kobald’s images of a 3D-printed model for a library project was reposted by @superarchitects, garnering over 3000 likes. On our site, however, the image had gotten only 40 likes. Kobald, now studying at MIT, remembers the moment: “I found out about it [the reposting by superarchitects] after landing in Vancouver airport for Christmas break and I received messages from five or six of my classmates with links to the page. It did lead to some messages from people asking how the model was made as well as some additional follow requests on Instagram and LinkedIn… it was pretty cool to be featured. It showed me a larger and highly public collection of student work than I was aware of” (personal email from Alex Kobald, 9 January 2016).
This image specifically demonstrates many aspects of Instagram we described earlier. Given that it was the time of studio reviews for many architecture schools, the account @superarchitects initiated the hashtag #SAstudio to collect as much studio work to one link. So we used the hashtag as shown in the below image, in addition to our trademark hashtag. @superarchitects regrammed our image, which resulted in increasing our followers by over 50 users in a few hours.

In a similar fashion, on June 7, an image from professional Masters student Michael Fohring’s thesis was reposted on @IMadeThat, a site developed specifically to showcase projects and to inspire architecture students from around the globe. The account was launched by the Association of Collegiate Schools of Architecture (ACSA) as part of an outreach communication campaign. IMadeThat’s feed is built around reposting images already published by the architecture school accounts. In order to get connected, images have to be tagged #IMadeThat.

And even more recently, two McGill images were reposted on @next_top_architects: the model produced by the McGill team who participated in the Tonjing Construction Competition in China last summer and a rendering of b-shack, a community-based project produced by FARMM (a research lab in our school) constructed on the Macdonald [the agricultural] campus of McGill University, attracting 151 and 2,611 likes respectively, and dramatically boosting the number of followers to the school site. These three sites, @next_top_architects, @superarchitects and the above-mentioned @IMadeThat, we would suggest, are particularly powerful.
We are constantly questioning the likes we get for images we post. We try to understand what is behind the number of likes an image would get over another one. This topic frequently generates e-discussion among the four of us who manage the account. This can be clearly demonstrated in the illustration below. Using a special website, we measured responses to our year of images. The resulting nine images demonstrated an unexpected variety. As you can see, the top nine are very different from each other: three renderings, two models, a watercolour painting, two shots of students, and a wall of traditional, hand-drawn work. They garnered between 90 and 165 likes.

With regards to a literature review on this subject, note that there is only one serious paper on Instagram: Alexandra Lange, a highly respected architectural critic based at Harvard University has written about the Instagram presence of starchitect Bjarke Ingels: www.dezeen.com/2014/01/07/opinion-alexandra-lange-on-how-architects-should-use-social-media/.

Ingels’ Instagram account is quite different than most architects. Firstly, it has 119,000 followers. And he offers glimpses of his private life that no doubt add to his reputation as a man about town. As Lange points out in her list of images that characterize Ingels’ account, “Selfie, LEGO selfie, girlfriend [I hope], Gaga, monograph, fog, fox socks. His Instagram has a lot to do with the architecture of self-promotion, but little to do with actual building.” It is more like People magazine than Progressive Architecture, that is for sure. The point of her article, however, is to urge architects to use Instagram to write a draft of history, introducing viewers to what they are thinking, reading, seeing rather than letting others do it for them. In her delightfully frank writing style, Lange warns architects to “let the rest of us in, so it doesn’t take bankruptcy, demolition or obituary to get people talking about architecture.”

CONCLUSION

As we hope is evident, we are enthusiastic about the role Instagram can play in architectural education. To investigate such a notion, we are constantly monitoring other accounts. This surveillance pushes us to be more selective when posting our images. We have also noted an invisible spirit of competition among schools of architecture that can be read in the images and associated hashtags.

We have also reaped the benefits of connecting with potential donors through our site. In this regard, an aspect of the project which show’s Instagram’s potential to stand in as a
virtual “visit” to the school. As a result, McGill’s advancement professionals have been huge supporters of our Instagram initiative. Charlotte Niedermann, Development Associate in the Faculty of Engineering, reports: “I use the School of Architecture Instagram account as an alumni engagement tool. The account is a great way to connect alumni to the School, especially those who live far away or aren’t actively involved with the School. The alumni can see with their own eyes the calibre of our students and their work. The posts share the School’s traditions as well as illustrate what has changed over the years. The account also communicates the impact of philanthropy at the School. It is an effective tool in the stewardship of our major donors and has the potential to inspire philanthropy in other alumni” (personal email from Charlotte Niedermann, 9 January 2016).

One issue we think merits further study is the relation between the number of likes an image gets and a project’s real-life grade. Our preliminary observations on this are that the two measures, likes and grades, are not parallel (or are non-conforming). Not accounting for time of day and other important factors, for example, and focusing only a third-year library project in which many projects were posted (in three phases), we note that the project that received the most likes (as a final rendering), received the same grade as one that received far fewer likes. Similarly, and as a cross checking measure, we note that the project that was considered by the instructor to be the “most resolved” was ranked only third by Instagram followers. As our work continues, we will likely discover that the time of day, the context of posting (alone or in a series), and other “environmental” factors may have an influence on the people’s choice. And we acknowledge that such factors might also affect good old-fashioned grading by professors.

As is well known, social media is hard to control. For instance, there is a popular trend in social media platforms and specifically on Instagram: “follow me and I follow back.” This tit-for-tat is misguided. Also, some hashtags are only designed to attract attention. An example of this is #tagsforlikes. Several scam accounts have liked our images and have followed our account in order to boost their own followers.

Before too long and following this preliminary presentation, we hope to co-write a critical paper on the architectural discourse generated by the three Instagram sites (@superarchitects, @IMadeThat and @next_top_architects) and to do a systematic study of @IMadeThat, in order to understand which student work is chosen and why. What are the ethical and philosophical implications of these connections? Since the so-called digital revolution, for example, critics have noted that architectural production has been homogenized. Certainly in schools of architecture admissions committees commonly note that portfolios look more alike than ever before. An increase in team projects over the past ten years, too, has meant that students graduate with portfolios comprised of shared projects. What does this mean for the future of architecture?

Finally, we underline that based on our recent experience, Instagram has rich potential to improve the basic level of communication within schools. Students and profs alike have noted how much they enjoy knowing what their colleagues are doing in such a fun and easy way. We have thus learned a lot about ourselves through Instagram and our efforts to produce an academic “selfie.” All of you are part of that power too. Look for images of our presentation today on mcgill_architecture soon.
REFERENCES


Towards a connected curriculum in architectural education: research-based education in practice

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ABSTRACT
This paper outlines a long-term flexible education strategy for integrating research and teaching at a research-intensive UK university. The “Connected Curriculum” is part of a recently launched twenty-year vision and a wholesale commitment to changing programmes of study. It will enable students to participate in research and enquiry throughout their education. In addition, it aims to allow students to make connections both vertically across a programme’s year groups and horizontally across disciplinary divides, as well as beyond the university setting. The paper begins by outlining the Connected Curriculum, including its framework of six dimensions of connectivity. Then it moves to look specifically at research-based education in practice. In doing so it pulls together a number of relevant curricula examples from built environment disciplines and further afield, which have clear implications for architectural education. Through illustrating relevant international and interdisciplinary praxis, in the context of an internationally-recognised strategic approach, the aim of the paper is to inspire curricula enhancement relevant to diverse architecture programmes.

INTRODUCTION
Change is affecting higher education globally in a number of ways and universities must adopt flexible yet coherent strategies that prepare students with the skills needed for successful and thriving careers in an unpredictable future. A growing body of literature argues that one way this can be done is by enhancing synergies between teaching and research. Bringing students closer to research has a number of benefits relevant to students’ current experiences and careers as graduates. These include motivating students through treating learning like research cited at the edge of knowledge discovered through collaborative and shared enquiry. University College London (UCL), a leading UK research-intensive university, has implemented a distinct research-based education strategy, known as “Connected Curriculum”, which is increasingly drawing the attention of the international higher education community. This institution-wide approach focuses on making learning and assessment relevant to what students will do in their future careers and on facilitating opportunities for connections. Importantly, though, this strategy takes a non-prescriptive approach: it offers suggestions for research-based education in unique subject-based contexts. The focus of this paper, then, is to use the framework of the Connected Curriculum to inspire architecture educators to develop more enhanced research-based curricula.
The discipline of architecture is ideally suited to lead the way in research-based education. In many ways learning and research already go hand in hand in architectural education. The design studio project is a strong example of collaborative and individual learning in a research setting. And through authentic assessment activities, students present to and engage the community beyond the university – specific points encouraged in the Connected Curriculum. Along with showcasing this and other strong examples already taking place, this paper also makes the case that there are ways in which architectural educators could enhance their own research-based offering. There is much to learn by looking beyond the limits of the discipline to strong curriculum design in other areas. It is argued that research-based education in architecture can contribute to and enhance an already established tradition of authentic learning in a community of practice.

The paper is conceptual in nature, however by way of secondary research it draws on an internationally-gathered collection of existing curricula enhancement case studies. It looks largely to the collection of case studies put together by of higher education consultants and developers Mick Healey and Alan Jenkins (2016), as well as from examples at UCL. The structure begins by both highlighting the value of research-based education as well as unpacking UCL’s approach. Finally, using the flexible framework adopted by UCL, the last section zooms in to the practical level. It sets out a number of diverse curriculum enhancements that may inspire architecture programme leaders. While these are framed in the context of a UK institutional strategy, the examples are relevant beyond the local context and to other disciplines.

A RESEARCH-BASED EDUCATION STRATEGY: THE UCL CONNECTED CURRICULUM

UCL and other institutions are beginning to adopt research-based education strategies in response to a shifting higher education climate. Barnett suggests the role of the university is changing where it must increasingly prepare students with new ways of knowing, in order to thrive in an unknown future. He notes: “In an age of supercomplexity, a new epistemology for the university awaits, one that is open, bold, engaging, accessible, and conscious of its own insecurity. It is an epistemology for living amid uncertainty” (Barnett, 2000; see also Brew, 1999). Brew (2012) identifies other changes which are also affecting the way universities are operating, including the shift to massification (Elton, 1992; Westergaard, 1991) and time pressures on academics (Hattie and Marsh, 1996). A growing body of literature (Brew, 1999; Brew, 2012; Hattie and Marsh, 1996; Healey 2005) argues that bringing students closer to research, employing pedagogic approaches which engage learning as shared discovery or enquiry, will go a long way to improving contemporary education. Learning through research can deepen learning and understanding, especially when it enacts inquiry-based learning, and learning which closely parallels problems found in one’s future career (Healey and Barnett, 2005; Healey and Roberts, 2004). The urge to bring teaching and research closer together is also driven by university managers to remove a long-standing binary which sees both areas as separate and unproductively disparate. This is evident with the ideas “teaching load” (what academics have to do) and research reward (what scholars are rewarded for doing) (see Fung and Gordon 2016). The challenge is for universities to reshape curricula so that staff and students can work together to treat learning as a journey; academics are further along the spectrum, and both staff and students develop through research and enquiry. Such an approach would reconceptualise higher education as “communities of practice” (Brew, 2012; Wenger, 1998).

The Connected Curriculum is UCL’s institution-wide strategic approach to reinvigorate learning in this way. President and Provost Professor Michael Arthur remarks that “our
top strategic priority for the next 20 years is to close the divide between teaching and research. We want to integrate research into every stage of...” education (Arthur, 2014). Recognising that the term “research” is discipline and subject specific, from the outset such a whole-institution approach encourages local and distinct adaptations. The Connected Curriculum framework (Fung, 2015a; Fung, 2015b; Fung, forthcoming a) was designed to operate as a flexible tool for programme leaders and others with a stake in education planning to think through the development of their offering (Figure 1). It also invites staff and students to “question critically the nature of evidence and knowledge production” in their own and in other subject fields (UCL, 2015d).

The core principle is that students learn through research and enquiry. Six dimensions of activity each branch out from this core, which invite teams to think about approaches to learning and opportunities for connecting learning beyond the classroom.

Dimension 1 encourages students to connect with staff and to learn about ongoing research. It hopes to both break down unproductive hierarchies between staff and students, with students able to ask questions, and to bring students closer to a part of university life that they traditionally never experience. Curiously the thing that drives institutional reputation is often removed from student experience. This is also about introducing students to many members of the research community of practice that they belong to.

Dimension 2 encourages a connected sequence of research activities throughout students’ programmes. It is important for development and learner scaffolding (Rosenshine and Meister, 1992) that students have opportunities to learn through research and enquiry at every phase of their degree. While the “capstone” dissertation project is encouraged as a minimum, there should be structured opportunities to develop expertise in research throughout earlier years, both within the curriculum and through extra-curricular activities.

Dimension 3 recognises that research is inherently social, and in order to strengthen the community of practice opportunities need to be structured which encourage students to connect their learning across the subjects they are taking and with the wider world beyond. It would be unhelpful for students’ future careers and lives if their education was not applicable to contexts beyond their immediate learning environment. Through this dimension students will have opportunities to connect with external organisations and communities.
Similar to dimension 3, students need opportunities to make connections between the research and learning they undertake on a course with what they will be doing in their future careers. Dimension 4 encourages students to connect academic learning with workplace learning, and in so doing will be able to develop a range of professional attributes and skills needed to succeed in modern work environments.

Dimension 5 focuses on assessments and invites programme teams to reconceptualise them as relevant and appropriate for the development of skills needed for students’ future careers. Is an essay or unseen final exam actually the best form of assessment? Possibly in some cases, but ideally some assessments will engage an audience beyond the marker, giving students a voice beyond the immediate activity, including with the community, industry partners, or employers. Arguably students will also learn more useful transferrable digital skills, through, for example, producing a video or website. Motivation is a key factor in rethinking assessments as outputs, with many students excited about the possibilities.

Finally, dimension 6 encourages interpersonal connections. The ability to work with and connect with people from different disciplines, cultures, and backgrounds is an increasingly valuable skill in a globalised economy. Students need opportunities to connect with other students in upper and lower years, on other programmes, and with people beyond the university, including alumni. While these connections may need to happen naturally, structured opportunities within the curriculum will be needed in order to develop a thriving research community.

RESEARCH-BASED EDUCATION IN PRACTICE

The Connected Curriculum framework is sufficiently flexible yet thorough to inspire enhancement in architectural education (as well as all disciplines). The six dimensions discussed above are by no means new to pedagogic approaches that already exist. There is a strong tradition in architecture of students learning through research and enquiry. Importantly, Connected Curriculum aims to inspire further enhancement on the back of this firmly established approach to education, while encouraging authentic learning in a coherent community of practice.

If one thinks of architectural education, likely the image of design studio comes to mind; indeed, in many schools it dominates both staff and students’ workload and energy. The studio, both timetabled learning hours and physical space, strongly fosters a research community. Students spend great lengths of time in the studio working on coursework, well beyond meeting with teachers about progress and feedback. For many students, desk space is also provided, which further adds to the sense of belonging. Students conduct practical research into the built environment, engaging websites, books, model making, computer drawing and experimentation. The dominance of the studio suggests that architecture students regularly engage in the core ideas of research-based education.

In line with the Connected Curriculum, studio learning can be linked to many of the framework’s six dimensions; at UCL the goal is to enhance these dimensions where possible. Often course teachers establish a theme for the cohort’s projects, which may be based on their own academic research; if so, students have the opportunity to learn through making connections with staff and their research [dimension 1]. In that studio takes place at every step of the way, ideally building on the work of previous years, a throughline of research activity is firmly established [dimension 2]. It is worth reminding students that studio is research and that it is a progressive journey of enquiry. In some cases, in line with dimension 3, studio is closely linked to work in other subjects, for instance architectural
history and theory or technology courses. Firmly situating and encouraging cross-subject connections reinforces the importance of learning in both subjects and allows students to develop through related yet distinct research projects. Aligning studio projects with other disciplines, for instance town planning, or engineering, further enhances connections relevant to students’ current learning and essential skillset needed for future employment. Though setting research projects in studio that relate to what students will be doing in diverse careers (dimension 4), including but not only in architectural practices, students will gain practical job developmental skills which can be motivating and underscore the relevance of the learning exercise. The activity of inviting external critics to view coursework, where students present their projects to relevant interdisciplinary professionals (the “crit”), is a further strongpoint linked to dimension 4. Studio work often culminates in the production of outputs directed an an audience (dimension 5). As well as the interim and final crit presented to invited guests, it is increasingly popular for schools to showcase studio research in end-of-year exhibitions or shows (as illustrated in the now-lengthy UK summer architectural calendar). Finally, through the above noted studio pedagogic approaches, especially the end-of-year show, architecture students are able to make connections with each other, across phases and with alumni (dimension 6). Further opportunity to showcase studio work throughout the year and invite others to view work in progress would also encourage greater connections, leading to further motivation and a strengthened research community of practice. While studio is so firmly established, it and other architectural courses can be enhanced through looking to, and being inspired by, relevant international work on research-based education in practice. The following is just a small sample of the many ways research-based education could be adopted in practice.

DIMENSION 1: CONNECTIONS WITH STAFF AND THEIR RESEARCH

While the studio can bring students in contact with academic research, this is not a guarantee, and indeed it may be that the theme is driven simply by an interest in the area; further it may not introduce students to a wide range of the department’s teaching staff. Structured opportunities for students to engage course leaders, and others in the department, are needed, which facilitate opportunities for diverse connections and introduce students to the strong research community they are part of. Some students do not realise academics even conduct research outside of their teaching commitments, others may feel that they are not allowed to even inquire about this. To overcome this unproductive binary between teaching and research at UCL there has been a history of creating induction-week activities which require students to enquire into staff research and report back on their findings. In the department of geography tutorial groups have been allocated a member of academic staff and each is then provided with three pieces of writing and a CV, and an interview is organised. Students then go off in small groups to read the material and devise interview questions to uncover the objectives of the interviewee’s research. As well, students find out how the research relates to his or her earlier studies, and how it relates to current teaching, other interests and geography as a whole. Finally, students produce a short report on their findings (Dwyer, 2001; Healey and Jenkins, 2016 [all references are to case study numbers]).

Other areas of the university, such as the Faculty of Brain Sciences, have modified the approach. In this case students view polished, short videos of academics speaking about their research so that they can ask challenging questions about scholars’ areas of expertise. Students are required to present on the findings (Fung, forthcoming b). The design of the activity means that students are able to develop a number of skills: teamwork skills; transferable skills such as project management and interviewing; and communication and presentations skills. Importantly, this exercise introduces students to the wider research
culture within the faculty (Standen, 2015). “Meet Your Researcher” (UCL, 2015e), as the idea is now known locally, which is adopted in various guises, is being encouraged in all departments; it would certainly suit architecture, where interesting yet diverse research is being conducted within one community.

The Science Faculty at McGill, Canada, has undertaken a similar but distinct sort of approach. Twice per academic year a handful of academic staff talk about their research in short casual presentations, and then students and staff have lunch together, informally discussing the research. This clearly works to break down unproductive binaries between staff and students, leading to the latter feeling comfortable enough to approach the former to ask questions.

Another way that students can make connections with staff and their research is by supporting the research itself. While research assistants are firmly established in some departments, designing an assessment activity could be a productive way to bring more students in contact with academics and their research. It is possible that students could even help with, for instance, data collection. This could have a number of ramifications for architecture, for example students could help gather GIS information and they could help conduct large-scale spatial studies through inputting data. One example from biology shows the scale and potential for motivating students. At the University of Sydney, Australia, a first year cohort of 1000 students carry out a small research project as part of a larger study of asthma across the metropolitan area. Students gather airborne fungal spores, in their backyards, over a ten-minute period. They learn how to identify the fungi and develop a distribution map of the spores. They then have the opportunity to discuss the cohort’s findings with the scholar and international expert. The activity led to a better awareness of the research process and the course content (Healey and Jenkins, 2016; Taylor and Green, 2007).

**DIMENSION 2: A THROUGHLINE OF RESEARCH ACTIVITY IS BUILT INTO THE PROGRAMME**

As noted above, in order to strengthen a research community and remind students that they are contributing to a shared construction of knowledge, drawing attention to the throughline of research is essential. In some cases, it could mean renaming courses to make this explicit. In most cases holistically mapping a constantly evolving curriculum rarely happens, yet this may be a useful way in which to identify the demand for a research throughline.

At the University of Tasmania, Australia, a structured and logical progression of research learning takes place throughout the full three-year undergraduate programme. In the first year assessment activities allow students to engage with researcher positionality and institutional ethic applications. Students work with real research data in year two. In the final year dissertation research is supervised by academic staff and both work together to produce a research paper for an undergraduate journal (Healey and Jenkins, 2016). A teacher could run with this and set an assessment task to write an architecture journal article, in the style and requirements set by a publisher (see also UCL, 2015b). Or students could be assigned a project to investigate an architecture journal article and put questions to its author, engaging in possible dialogue with the scholar (Healey and Jenkins, 2016). While most architecture programmes are professionally accredited and rigid, a number of small interventions could be made to establish a throughline of research. Encouraging research community activities such as research seminars, departmental conferences, and student-led research journals and digital platforms for the dissemination of coursework would further reinforce the research community which students are a part of throughout
the duration of their studies. Moreover, these would not require major revisions to the programme structure.

**DIMENSION 3: STUDENTS MAKE CONNECTIONS ACROSS SUBJECTS AND OUT TO THE WORLD**

Through making practical connections between immediate learning and other courses and beyond, students will be better equipped to apply the skills of research and enquiry to global problems in the future. All first year engineering and computer science students on the Integrated Engineering Programme at UCL work on two five-week long research problems based on real challenges. This includes identifying the problem, designing the research project, and finding a solution. In that the problems are based on global challenges, such as sustainability and health, students work closely with teaching staff and external experts (Healey and Jenkins, 2016). These problem-based scenarios, situated in real global challenges, offer authentic learning similar to what graduates may do in their future careers.

Learning with objects is a closely related pedagogy also useful for encouraging students to make connections across their learning out to the world beyond (Chatterjee and Hannan, 2015). At the University of Strathclyde, UK, first year mechanical engineering students work closely with a car, disassembling it, and selecting a component for investigation. They research its functions, physics, design and manufacture, and produce a poster explaining their research (Healey and Jenkins, 2016). At UCL, similarly, second and third year architecture students recently visited the UCL archive collection. The studio group was investigating remoteness and were particularly interested in the story-telling abilities of artefacts. Students were able to view and handle a number of objects, including a rocket designed to be fired onto the Moon, a number of letters and photographs sent home from arctic explorers, and rocks from remote St Kilda, UK – the location of the group’s upcoming site visit.

Situating learning in the city or landscape is another key way students can make connections between course material and the world beyond in a research-based setting. Students in architecture, construction and project management and planning come together for a large first year course at UCL. “Making Cities” uses contemporary London as a research laboratory, with students required to investigate a component or area of the urban fabric through videography. Similarly, “Making History”, also at UCL, encourages students to use the resources around them in the city – archives, documents, objects, collections, buildings, images, and soundscapes – to creatively investigate London’s history (UCL, 2015a; Fung, forthcoming b).

**DIMENSION 4: STUDENTS CONNECT ACADEMIC LEARNING WITH WORKPLACE LEARNING**

Built environment disciplines tend to have close links with the community, which bolster connections between learning and work. Many engineering programmes are developed to work closely with firms who also help create assessment activities that respond to real community problems. Construction and project management programmes similarly work closely with industry and regularly schedule site visits. It is clear that employers benefit from educating the next generation of professionals: they want to be well-placed to hire new graduates. In architecture, students often see the link between studio work, or technology courses, with employment. It is clear to them that learning and assessment parallel tasks in work. However, the connections between other parts of their curriculum and workplace learning, such as architectural history and theory, may be less clear to students. The need...
to reinforce the importance of foundational history goes without saying, but there may be other ways that help draw clear links with employment and which have the added benefit of increasing motivation. One is to encourage students to undertake historical projects that are needed or parallel the work of national historical societies for architecture. Could English Heritage, for instance, help identify essay topics or could historians from the organisation speak to architecture cohorts about their careers?

The Science Shop model has been well established in other countries and disciplines. It links up undergraduate students in need of a dissertation topic with civil organisations in need of research. It gives students an opportunity to lead their own research project, attempting to answer a real problem in the community. A key part of this is taking advantage of institutional support, public engagement teams and university volunteering departments, who are well-placed to understand the needs of the community and who are keen to encourage partnerships. Working on these real research problems gives students a way of applying their learning to what they may be doing in their careers, and supporting a charity with their expertise.

Like the Science Shop model, architecture students at The University of New South Wales, Australia, offer a relevant example of community engagement through research. Shaped by the needs of community partners, programme leaders set out a number of projects for students to work on solving in teams. After a research and design phase students then present their solutions back to the community (Healey and Jenkins, 2016). Students clearly see the relevance of their learning to what they may do in their careers; they understand the importance of research and enquiry and how it leads to design solutions.

**DIMENSION 5: STUDENTS LEARN TO PRODUCE OUTPUTS – ASSESSMENTS DIRECTED AT AN AUDIENCE**

Architecture education has many outward facing assessments; both the crit and the final year show (both discussed above) speak to the way in which assessments engage an audience beyond student and marker, producer and consumer. While many programmes have unseen final exams, in architecture this is usually not the case; summative marks tend to be awarded for final projects. Where architecture assessment activities could be revitalised is through exploring ways in which written assignments can serve a purpose beyond the immediate assessment activity and engage an audience beyond the marker. Little motivation can be found in writing an assignment solely for a marker, which then gets filed into an archive. One way students can engage an audience is through creating a Wikipedia page on a relevant previously-unreported component of architecture. Students could then follow it, and defend it through the review process. Another way is through drawing students’ attention to research exhibition opportunities. The British Council for Undergraduate Research – paralleling similar national organisations in other countries – has been set up to give opportunities for students to showcase final-year research projects to a national community. A related Posters in Parliament event, allows a select number of students to present their research in a prestigious setting to Members of the UK Parliament. Even arranging a local undergraduate research conference (Healey and Jenkins, 2016) would allow students to think of their research as serving a purpose beyond the assessment activity. This would help strengthen a research community, and it would help students learn valuable presentation and research synthesising skills.

Fourth year anthropology students at McMaster University, Canada, work together to produce an edited book collection. The teacher sets the overall theme for the cohort, each student produces a chapter, and together they collectively learn about book proposals,
editorial and production (Healey and Jenkins, 2016). The move to open-access and digital publishing may mean getting student work published could be even easier. To improve on this model, a course leader could assign the book topic in the first year, with three successive cohorts adding to the book. This would allow an internal selection process of the best chapters. A digital webspace or internal newspaper production, could allow full and more immediate publication.

Architecture students at UCL have a long history of producing assessments for an audience. In 2014 a group of second year students were given a brief to create an exhibition on a well-known and important architectural figure that once taught at the school, Reyner Banham. Throughout the term, students conducted research and designed a small exhibition which was mounted in the school’s architectural library. Through uncovering local history, students were able to learn through research and enquiry and to produce an assessment activity that was outward facing and engaged a wide audience. Similarly, in 2015 a design studio group of students at UCL produced short films which were exhibited at one of London’s Curzon Cinemas. The activity asked students to step out of the comfort of their familiar studio and to deploy their work in a public arena. In attendance were a number of invited guests, including filmmakers, artists, designers and architects, teachers, parents and friends. All guests were asked to both rank the films out of five stars and to offer a few words, which students were then able to put on their film posters. Students found the assessment activity quite entertaining and were proud to showcase their work to an audience.

**DIMENSION 6: STUDENTS CONNECT WITH EACH OTHER, ACROSS PHASES AND WITH ALUMNI**

The nature of the architectural crit, if it is open and welcoming of others, and the final year show, are two ways in which architecture students have opportunities to connect with each other. The challenge of connecting with alumni can be also overcome to some extent if architecture schools are active in encouraging graduates to return for these events. While there is likely room for improvement in many ways along these lines in architectural programmes, the “Making Cities” course at UCL, discussed above, which puts students in interdisciplinary teams is a structured example of encouraging students to connect across disciplines. In fact, understanding professional relationships in the built environment is one of its aims. As a first year first term course, students have the opportunity to understand how three professional disciplines contribute to the makeup of the built environment, and also to learn the challenges, rewards, and necessity of connecting across disciplinary boundaries (see also Edwards, Campkin and Arbaci, 2009).

Also at UCL, postgraduate students in the Development Planning Unit work closely with several sites in the global south. Each programme has a particular site and set of partners / community groups that they work with over three to five years. Students investigate the site, producing a policy brief detailing what could be done to ameliorate a problem. While the nature of the 12-month course, which includes just a short field trip to the site, is compressed, students connect with successive cohorts who in turn visit the site and monitor progress for continuity. What originally may have been a challenge, means that students are able to learn how to bring a project to a milestone in order to pass it on to others, while connecting with future generations that they do not even meet. This approach has also been taken in undergraduate courses in Science at UCL (Chang, 2007; Healey and Jenkins, 2016). Finding more innovative, structured, and serendipitous ways to allow students to connect with each other is an ongoing challenge.
CONCLUSION

This paper began by unpacking the UCL Connected Curriculum, an institutional response to research-based education, and its six dimensions of connectivity. It then went on to frame this in the context of tangible local, national and international curricula examples. In doing so it modestly aimed to inspire curricula enhancements in architecture and beyond. While architectural education has much to celebrate for its pedagogic innovation and its firmly established tradition of authentic learning in a community of practice, the principles of research-based education promises further enhancement. Designing architectural programmes that encourage curiosity, and that allow students to participate in research and enquiry in a community setting, will arguably enhance the student experience in a number of ways. Specifically, a Connected Curriculum in architectural education can: reduce unproductive hierarchies between student and teachers; foster a spirit of shared uncertainly in real problems; allow students to learn about and engage with a part of university esteem that often goes unnoticed; connect students across disciplines and years, as well as build links between students with alumni, employers and the community; and motivate students with assessments that both engage an external audience and are relevant to what one may do in an architectural career. Through realistic career-like problem-based learning, curricula should foster curiosity that speaks to the ways in which academic research is situated at the edge of knowledge. Through inculcating a spirit of community, establishing a department where students can engage in academic research, students will be able to participate in an authentic community of research practice. Finally, through valuable assessment activities, students will be able to contribute to the production of knowledge at their institution.

It is true that an institution-wide strategy of this size and duration may face its challenges and sceptics (UCL, 2015c), and that some students may be initially put off by its demands for collaboration and critical thinking, but as suggested above, the discipline of architectural education is already doing so much along these lines. Few will doubt that the Connected Curriculum’s flexible dimensions of good research-based education will lead to a rewarding experience for all, and ultimately valued architectural graduates.

REFERENCES


ABSTRACT

The exact territory of architects and engineers has long been contested, ever since the separate professions emerged out of the industrial revolution. During that era the need for specialist exploration and regulation of the application of scientific knowledge, was fulfilled by the creation of the engineering profession. Engineers’ certainty in describing their roles in designing our built-environment is founded on the seemingly unquestionable necessity of their involvement, to ensure safe and economic designs, through the application of evidence-based research methods. Their design methodology can be seen to be fulfilling their role and evaluating their contribution simultaneously. This contrasts against the intellectual interrogation of different design methods throughout the history of the architectural profession and the challenge faced in demonstrating the value of architectural design.

The expectation of the current architectural and engineering education systems might be that, through their accreditation by the respective professional bodies, they reflect and reinforce professional boundaries. However across all disciplines there is now an increasing requirement for different disciplines to work together on big challenges. Reflecting on such collaborations in all disciplines, recent published work questions whether interdisciplinary research bridges, dissolves or further deepens divisions. Using theories of interdisciplinary research and education this paper compares the accreditation criteria of both the architectural and engineering professional bodies and collates data on interdisciplinary programmes to analyse the division between the two education systems.

THE CASE FOR INTERDISCIPLINARITY

The word interdisciplinary has become a very commonly heard term across teaching, learning and research in Higher Education and it has acquired a multitude of definitions as well as its own research field. Proliferation of this term could perhaps be cynically attributed to the governmental identification of bridging disciplines as an attractive activity in education (The National Committee of Inquiry into Higher Education, 1997) and to maintaining cutting edge research in the UK (HM Treasury, 2004). Specific funding streams have been identified in UK Research Councils for interdisciplinary research with the latest thinking to have separate interdisciplinary review panels and even to directly allocate funds by top-slicing the UK Research Council budget (Nurse, 2015). However the pressing nature of present-day world challenges such as climate change, water shortage and food security genuinely seem to demand the bringing together of skills and knowledge from across established disciplines. As technical issues that are associated with
building design increase so too has the need to understand how they can be effectively applied to take account of human factors.

There have been many recent calls for both engineers and architects to develop a deeper understanding of each other’s disciplines, such as in the report written for the Ove Arup Foundation on interdisciplinary education: “With the future of construction activities heading towards total solutions and large and varied projects, the need for interdisciplinary skills is likely to increase. Universities and industry should not fear this change, The findings suggest interdisciplinarity can be a strength not a weakness in the education system” (Gann and Salter, 1999). Gann and Salter (1999) are however careful to note that for engineering the inclusion of interdisciplinary skills in education should not be at the expense of high quality technical education.

Doug King’s report The Case for Centres of Excellence in Sustainable Building Design (King, 2012), written for the Royal Academy of Engineering, sets out to quantify the number of interdisciplinary professionals required to implement government initiatives to tackle climate change. He uses this data to make the case for Centres that promote interdisciplinary education in the UK: “The primary aim of the proposed centres of excellence is to enhance the education of building designers, within a multidisciplinary environment, so that they are equipped to deliver the low carbon buildings using the most economic and advantageous techniques.” (King, 2012).

The report The Future for Architects (Building Futures, 2010), written with the support of the Royal Institute of British Architects (RIBA), records the recognition by students from both professions of the contribution that architects make to the design process but also the opinion of engineering students that architects may need more technical skills to compete in the construction industry: “Both the engineering students and the architects agreed that the architecture profession brought a ‘social science’ aspect to the building process that engineers often lacked. However, the engineering students believed the engineers of the future would be leading the production of buildings, unless architects became more skilled in engineering.” It is interesting that in the same report architecture students also felt restricted by the title architect and wished to have more diverse options on graduating (Building Futures, 2010).

Pathways and gateways: the structure and regulation of architectural education (The UK Architectural Education Review Group, 2013), a report sponsored by the Standing Conference of Heads of Schools of Architecture, recognised similar issues. It recognises an increase in the role of the engineer and interestingly that that is coupled with a move away from design-led practice: “The last five years have seen the unprecedented growth of integrated consultancies whose appetite to swallow up smaller firms seems to know no bounds. These practices are spread globally and employ interdisciplinary staff. This type of practice marks a fundamental shift in the profession away from design-led practice towards a process-driven consultancy often led by engineers.” (The UK Architectural Education Review Group, 2013). Addressing these concerns the Farrell report (Farrell, 2014), whose expert panel included architects and urban designers, suggests that a common foundation year for all students of the built environment is needed and the report supports the view expressed in Pathways and gateways: the structure and regulation of architectural education that more fluidity should be allowed between the study of all professions in the built-environment.
Two approaches to interdisciplinary education could be identified from these sources. The first aims to broaden architecture or engineering education whilst maintaining the core knowledge and skills needed for each profession and the second possibility is where a new profession is created by bringing together knowledge and skills from both the existing professions.

THE DISCIPLINES

In order to define the term “interdisciplinary”, researchers have often found it to be necessary to define the term “discipline” first. A huge number of definitions are offered which can be broadly categorised as containing both or either of the following aspects (Barry et al., 2008; Klein, 1990; Nissani, 1997; Boisot, 1972):

1. An academic field of knowledge that has particular methods and common assumptions or axioms.
2. The social and cultural structures that represent and perpetuate the definition of a discipline such as the teaching and assessment of the discipline and the existence of representative University departments.

The evidence for the existence of social structures that define both architecture and engineering as disciplines is carefully set-out in *Architect and Engineer: A Study in Sibling Rivalry* (Saint, 2007). This book documents the professions’ divergence from the role of the master builder, with engineering pursing the new possibilities that the application of scientific methods offered the industrial revolution. Saint (2007) also reflects on the setting up of distinct education systems and another key social construct, professional bodies, whose existence helps regulate, represent and support those joining the professions through offering chartership as well as contributing to the validation of education providers.

The Institution of Civil Engineers (ICE) was founded in 1818. It was the first professional body in the world that represented and brought together professional engineers (ICE, no date). Later on in the nineteenth century a number of other professional bodies emerged to represent the increasing engineering specialisms, including the Institution of Mechanical Engineering and the Institution of Electrical Engineering. In order to determine the requirements and standards to achieve chartership in any engineering specialism a body now known as the Engineering Council (EC) was created in 1964. The EC also works internationally to ensure the recognition of UK engineering chartership in the global market (Chapman and Levy, 2004).

In 1977 the Joint Board of Moderators (JBM) was set up as a validation body, by several professional bodies including The Institution of Civil Engineers and The Institution of Structural Engineers, to assess degree programmes to determine their achievement of EC standards (JBM, no date). There are other professional bodies that validate programmes according to the EC standards such as the Chartered Institution of Building Services Engineering (CIBSE).

The professional bodies associated with architecture are fewer. The Architects Registration Board (ARB) is essentially the equivalent of the EC since it establishes the professional standards required for chartership and ensures that they fulfil the European Commission’s requirements. The RIBA was founded, much earlier than any of the engineering professional bodies, in 1837, and both represents the architectural profession and validates programmes to the ARB standards. The RIBA is therefore equivalent to CIBSE in the way CIBSE represents building services engineers and validates programmes to EC standards. However the RIBA
is the sole acting architectural validation body in the UK.

Through these structures industry should be able to work with academia in determining how and what emerging architects and engineers are taught and therefore form a feedback loop between what is taught in Universities and the current skills and knowledge required by each profession. The potential for the domain of a discipline to evolve is commented on by Squires (1992) who offers a definition of the term discipline which includes the need for disciplines to critically self-regulate through “reflexive analysis”.

Addis (1990) collates the comments of prominent engineers, from Pier Nervi in 1951 to Peter Duncan in 1981, who consistently observed the gap between the theoretical knowledge taught and the practical understanding required by the industry. Addis (1990) comments that: “The idea is thus encouraged that a structure has a single, unique model and, conversely, that a given model has a single and unique counterpart in the real world. Seldom is any mention made of the possibility of there being alternative models and that criteria are needed by which the alternatives can be judged and evaluated”.

It is clear that Addis is somewhat critical of academia as a preserver and generator of scientific theories and he observes a shortfall in critical reflection being exercised in understanding the assumptions and limits in the application of such scientific theories to the real world. This is reinforced by Addis’ definition of the titles, engineering scientist and engineering designer (Addis, 1990). Such a dislocation between academia and
**Table 2:** The EC (2013) academic requirements for an integrated Mining Course.

| A.5.4 Science and mathematics | 1. A comprehensive knowledge and understanding of scientific principles and methodology necessary to undertake their education in their engineering discipline, and an understanding and knowledge of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies.  
2. Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in the engineering discipline and to enable them to apply mathematical and statistical methods, tools and notation proficiently in the analysis and solution of engineering problems.  
3. Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline and the ability to evaluate them critically and to apply them effectively.  
4. Awareness of developing techniques related to their specialisation.  
5. A comprehensive knowledge and understanding of mathematical and computational models relevant to the engineering discipline, and an appreciation of their limitations.  
6. Understanding of concepts from a range of areas, including some outside engineering, and the ability to evaluate them critically and to apply them effectively in engineering projects. |
| 8.1.6 Engineering analysis | 1. Understanding of engineering principles and the ability to apply them to undertake critical analysis of any engineering process.  
2. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques.  
3. Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action.  
4. Understanding of, and the ability to apply, an recognised or systems approach to solving complex engineering problems.  
5. Ability to use fundamental knowledge to investigate new and emerging technologies.  
6. Ability to extract and evaluate pertinent data and to apply engineering analysis techniques in the solution of unfamiliar problems. |
| C.5.8 Design | 1. Understanding and evaluation of business, customer and user needs, including considerations such as the wider engineering context, public perception and aesthetics.  
2. Investigate and define the problem, identifying any constraints, including environmental and sustainability limitations; ethical, health, safety, security and risk issues; intellectual property, costs and practice and standards.  
3. Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate difficulties.  
4. Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem, including production, operation, maintenance and disposal.  
5. Plan and manage the design process, including the use of engineers, and evaluate outcomes.  
6. Communicate their work to a technical and non-technical audience.  
7. Demonstrate wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.  
8. Demonstrate the ability to generate an innovative design for products, systems, components or processes to fulfill new needs. |
| D. 5.7 Economic, legal, social, ethical and environmental context | 1. Understanding of the need for a high level of professional and ethical conduct in engineering, knowledge of professional codes of conduct and how ethical dilemmas can arise.  
2. Knowledge and understanding of the commercial, economic and social context of engineering processes.  
3. Knowledge and understanding of management techniques, including project and change management, that may be used to achieve engineering objectives, their limitations and how they may be applied appropriately.  
4. Understanding of the requirement for engineering activities to promote sustainable development and the ability to apply quantitative techniques where appropriate.  
5. Awareness of relevant require regulatory requirements governing engineering activities, including personnel, health & safety, contracts, intellectual property rights, product safety and liability issues, and an awareness that these may differ internationally.  
6. Knowledge and understanding of issues, including health & safety, environmental and commercial risk, risk assessment and risk management techniques and an ability to evaluate commercial risk.  
7. Understanding of the key drivers for business success, including innovation, calculated commercial risks and customer satisfaction. |
| F. 5.1 Engineering practice | 1. Understanding of contexts in which engineering knowledge can be applied (eg. operations and management, application and development of technology, etc.).  
2. Knowledge of characteristics of particular equipment, processes, or products, with extensive knowledge and understanding of a wide range of engineering materials and components.  
3. Ability to apply relevant practical and laboratory skills.  
4. Understanding of the use of technical literature and other information sources.  
5. Knowledge of relevant legal and contractual issues.  
6. Understanding of appropriate codes of practice and industry standards.  
7. Awareness of quality issues and their application to continuous improvement.  
8. Ability to work with technical uncertainty.  
10. Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.  
11. Understanding of different roles within an engineering team and the ability to exercise initiative and personal responsibility, which may be in a team member or leader. |
| F. 5.6 Additional general skills | 1. Apply their skills in problem solving, communication, working with others, information retrieval, and the effective use of general IT facilities.  
2. Plan self-learning and improve performance, as the foundation for lifelong learning (LOL).  
3. Monitor and adjust a personal programme of work in an on-going basis.  
4. Exercise initiative and personal responsibility, which may be as a team member or leader. |

**Figure 1:** Total number of degree programmes that are accredited either by CISE (2015b) or JAMU (2015) or both and which contain both engineering and architectural components.
the profession is not just observed in engineering but is also a source of concern for architecture, as discussed in detail in the RIBA’s Skills Survey Report (2014a).

The eleven general criteria required by the European Commission to become a chartered architect are set out in the EU Directive 2005/36/EC (EC, 2005). Each of these general criteria are adopted and developed into 3 sub-criteria to form the RIBA (2010) criteria (see Table 1) which are required to be addressed at both Part 1 (undergraduate degree level) and Part 2 (masters level). The general criteria range from a historical knowledge of different subjects, to knowledge of the fine arts as well as technical principles. Many of the subjects addressed have their own claims to be a discipline.

Groat and Wang (2013), writing in the context of architectural research methodologies comment: “Research into architectural realities is necessarily an interdisciplinary matter.” and go on to outline the wide variety of methodologies available noting their origins in science, social science and humanities. The lack of an established subject specific methodology in the study of architecture facilitates a critical reflection on the choice of methodologies appropriated for a particular research question. However this mode of operating opens out architecture to criticism due to a lack of coherent evidence to support design decisions and fragmented research fields. These difficulties are acknowledged in the recent RIBA report Delivering Construction 2025 RIBA Action Plan (2014b) alongside a call for more collaboration between practice and academia to enable the lessons learnt to be built on and there to be a stronger culture of evidence-based practice. Squires (1942) comments on the difficulty of defining geography as a discipline which has certain resonances with architecture: “… the breadth of the subject is enormous and the central core of theory holding it together is minimal”. This suggests that architecture as an education system as well as a profession might not fulfil all researchers’ definitions of a discipline.

The Engineering Council (EC) criteria (EC, 2013) require a strong basis in science and mathematics (see Table 2 A1-2 and B1). In this way a common language and methodology across all engineering programmes is assured and not just in those that are accredited by the JBM and CIBSE. This criterion is translated by CIBSE and the JBM into guidelines that ask for at least one third of the total curriculum to be spent on core technical subjects and that mathematics and its application is to be studied for at least 2 years of the degree programme. The EC criteria also ensures that the predominant design methodology is evidence based and quantitative (see Table 2 B1-6), so that every design calculation offers a quantification of the value of the engineers’ contribution to the process.

Despite the traditional academic aspects of engineering exhibiting a strong link to scientific methodology through a core syllabus Squires (1992) in fact defines the separate subjects of architecture and engineering as potentially already interdisciplinary subjects themselves. This is supported by the attempt by Gann and Salter (1999) to quantify the interdisciplinarity in all built-environment programmes, including civil engineering and architecture, by analysing the programme components. The data collected perhaps surprisingly suggests that civil engineering programmes have the largest amount of interdisciplinary content. This is qualified by the comment that as architecture is itself interdisciplinary the analysis as to what is a different discipline to architecture could be misleading.

INTERDISCIPLINARY EDUCATION

Karlqvist (1999) literally defines the term interdiscipline as “between disciplines” and
comments that it directly identifies a gap between disciplines that neither’s methods can address in order to generate new knowledge. Karlqvist’s identification of different types of gaps between disciplines are summarised in Table 3 and are linked to five possibilities for interdisciplinary research.

Given the desire in both professions for more interdisciplinary skills in graduates it is to be expected that the criteria required for degree programmes validated by engineering professional bodies will have some overlaps with the criteria required for validation by the RIBA. The extent of the overlap and the nature of the gaps between the subjects is much harder to define. Knowledge of fields such as building regulations, construction law as well as economics, health and safety and awareness of the roles of other construction professions could be seen as much needed common territory and are addressed in both criteria (see Table 1 GC6, GC10 and GC11). Whether there are significant differences in the methods used to teaching these subjects it is not clear. Here perhaps the gap between the subjects could be described using Karlqvist’s suggested assessment, as set out in Table 1, as being only mode 1 or, if the mode of teaching could be demonstrated to be similar, as having no gap at all.

Engineering education has traditionally required intense knowledge transfer to help students understand the mathematical models used to predict material, structural and environmental behaviour as set out in the JBM (2009) and CIBSE (2015a) accreditation criteria. The RIBA (2010) criteria in particular GC8 and GC9 (see Table 1) also require an understanding of structural, acoustic, lighting and thermal performance principles, although in the sub-criteria emphasis is also placed on understanding systems and strategies to integrate these principles in design. Based on the accreditation criteria it is relevantly easy to make the case that there is an overlap with respect to the technical principles taught but if the teaching methods used are inherently different, the actual learning outcomes might show a larger divide than the accreditation criteria suggest.

The criticisms of engineering education from Addis (1990) are not alone. Brohn and Cowan (1977), focusing on structural engineering education, note that: “The qualitative analysis of structures is an important topic in a structural engineering curriculum. Neglect of this section of the syllabus will entail the production of graduates whose ‘understanding’ of structural behaviour is unacceptably weak, when assessed by standards which are generally accepted in the profession.” Brohn and Cowan (1977) also note that qualitative analysis is unlikely to be learnt through quantitative methods. Such critical appraisals have had an impact on the teaching of mathematics, refocusing the requirements to teach the subject to support engineering analysis rather than for the pure academic merit of studying it (Table 2 Criteria A.1-2). This shift is also reflected in the significant focus of the

<table>
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<tr>
<th>Interdisciplinary gaps</th>
<th>Modes of interdisciplinary research</th>
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<tr>
<td>1. Doing the same thing in different ways.</td>
<td>Finding two things are different manifestations of the same underlying structure.</td>
</tr>
<tr>
<td>2. Doing different things that can be combined.</td>
<td>Different scientific experts contribute to an overall or composite picture using their own theories and method.</td>
</tr>
<tr>
<td>3. Doing different things that cannot be combined without an additional framework</td>
<td>A new theoretical framework is required.</td>
</tr>
<tr>
<td>4. Doing things differently.</td>
<td>Basic underlying assumptions and the paradigmatic bases for theories are different.</td>
</tr>
<tr>
<td>5. Thinking differently.</td>
<td>Fundamental interpretative and conceptual differences.</td>
</tr>
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</table>

Table 3: Interdisciplinary research (Karlqvist, 1999).
Engineering Council (EC) criteria on design (Table 2 Criteria C.1-6) as well as traditional analysis. Johnson and May (2008) suggest the need for more case studies and application of structural analysis in conceptual designs in engineering design education. All these modes of teaching technology are familiar to architectural educators and increasingly address the approaches implied in the RIBA (2010) criteria.

In recent years the JBM and CIBSE have therefore recognised that an academic understanding alone isn’t sufficient to make sure engineering graduates can apply, and apply creatively and critically, the principles they are studying. The accreditation guidelines for design projects were introduced in 2009 as Appendix C in the CIBSE (2015a) requirements and Annex B in the JBM (2009) requirements. They both state that “In engineering a central activity is design, and the interpretation and execution of design”. Design is recognised not as a linear process but as a highly iterative one. Engineering design projects that once were closed ended problems which could be solved using taught knowledge, are now required to be open ended problems, with complex contexts, where the brief can be questioned and where students are asked to use research skills to determine an appropriate way forward. The importance placed on the design studio as a key supportive environment by JBM and CIBSE is also a notable parallel with architectural design studios. The current EC (2013) criteria A.1 and Appendix C in the CIBSE (2015a) requirements and Annex B in the JBM (2009) require an understanding of the history of technology, which goes some way to achieving the RIBA (2010) criteria GC2. From this evidence the methods used in teaching design in engineering programmes are being encouraged to move closer to those used in architectural programmes. Again referring to Karlqvist (1999) this might suggest a classification of a mode 1 interdisciplinary gap. However it would still be very difficult indeed to argue on the basis of accreditation criteria that in reality there was no distinction between the two educational approaches to design.

An alternative analysis of the criteria could be that, despite the overlaps in content and an increasing convergence of suggested teaching methodologies, there still remains fundamental conceptual differences between engineering and architectural education. This would suggest that, with a mode 4 or 5 interdisciplinary gap, as described by Karlqvist (1999) in the context of research, there are large barriers to producing truly interdisciplinary outputs. Such an analysis might resonate with a perceived “rivalry” (Saint, 2007) between the professions but it would be very concerning as it would have a fundamental implication for engineers and architects being able to work together in practice to generate cohesive designs. It would also suggest that much more work needs to be done on the nature and outcomes of interdisciplinary education to overcome such differences.

Quite how the RIBA (2010) criteria and requirements of the JBM (2009) and CIBSE (2015a) relate is of course is highly debatable and potentially controversial. The increasing agreement on the focus on design and integrated application of technical knowledge as well as professional knowledge and skills result in some very closely related, if not similar required, knowledge and skills sets as set out in Table 1. There is a surprising degree of overlap which could well get larger as the pressure for architects to have more technical skills (Building Futures, 2010) as well as develop evidence-based design methods increases (RIBA, 2014b).

If the suggestion that there is a fundamental conceptual difference between the subjects is discounted, such an overlap supports the assertion that perhaps both architecture and engineering degrees are already inherently interdisciplinary. It also suggests, that given the potential existing overlap, what might be termed interdisciplinary degree programmes,
that bring together components nominally identified as engineering and architectural, are increasingly possible without reducing the integrity of either subject and in doing so be able to be recognised by both the RIBA and the JBM or CIBSE.

There is however currently no agreement between professional bodies that an accredited engineering programme would be recognised as fulfilling any part of the RIBA (2010) criteria for chartership (and vice versa). There are however instances where components which form part of an accredited architecture programme are also taken by engineering students as part of an accredited engineering programme.

**INTERDISCIPLINARY PROGRAMMES**

There are currently 48 Universities which run RIBA accredited architecture programmes and there are 18 Universities who run one or more programmes that, according to their UCAS descriptions, offer a mixture of engineering and architectural components. The number of such programmes is steadily increasing over time (see Figure 1) according to the lists of accredited programmes held by CIBSE (2015b) and the JBM (2015).

These interdisciplinary programmes vary considerably in what they offer. The architectural components range from being 25% to 70% of the assessed programme content (depending on how the architectural content is defined). The architectural components selected can focus only on architectural design projects or focus only on topics such as humanities and technology lectures or a mixture of both. The logistics of teaching these components can be different, from being taught by a local architecture department alongside students studying an accredited architecture degree to being taught as components run solely for the interdisciplinary programme. This can involve being taught by tutors directly employed by engineering departments. The engineering components chosen can also vary their focus from building physics to structural and civil engineering, but are predominantly taught in engineering departments.

All these interdisciplinary programmes are either accredited by the JBM or CIBSE. The majority of these programmes are currently unrecognised and unregulated by the architectural professional bodies (ARB and the RIBA), except in three cases; the BEng in Architecture and Environmental Engineering at the University of the West of England (accredited by CIBSE and RIBA), the MEng in Structural Engineering and Architecture at the University of Sheffield (accredited by both the JBM and RIBA) and the MEng in Architecture and Environmental Design, University of Nottingham (accredited by CIBSE and RIBA) (RIBA, 2015).

It is difficult for students to move at any point from studying engineering to studying architecture and gain professional recognition. It is not as difficult in terms of professional recognition to move from studying architecture to engineering due to the ICE’s Academic Assessment route which allows those holding qualifications unaccredited by the JBM or CIBSE to be assessed and where appropriate they are counted towards achieving engineering chartership.

It is currently extremely hard for interdisciplinary architecture and engineering programmes to gain and maintain architectural accreditation because:

1. The EU Directive 2005/36/EC (EC, 2005), enforced by ARB requires an accredited award to be principally in architecture. Principally is noted by the UK Architectural Education Review Group (2013) to be interpreted to mean 80% of its content. The
extent to which architecture may be defined as overlapping with other subjects may offer some room for interpretation.

2. The RIBA (2010) require “50% of credits” to be assessed via “design studio projects” at RIBA Part 1 (undergraduate degree) and Part 2 (masters) levels. For interdisciplinary programmes it is hard to achieve this requirement as well as achieving at both Part 1 and Part 2 levels all the specific RIBA validation criteria (which generally requires additional taught components to the design projects) and the requirements of JBM (2009) or CIBSE (2015a).

3. The RIBA’s (2010) required sequential completion of RIBA Parts 1 and 2 to achieve chartered status.

It also seems impossible for graduates from programmes which are not recognised by the ARB and the RIBA to achieve chartered status. This was once possible via the ARB prescribed examinations route as exemplified by the University of Newcastle’s Architectural Engineering MEng programme where students developed design portfolios and if they wished, they submitted them to the prescribed examination to be assessed for RIBA Part 1. This route seems to have disappeared with the ARB requirement for the prescribed exam seemingly requiring an academic qualification where architectural design projects form at least 50% of the assessed work.

The current architectural education system therefore cannot recognise potentially relevant knowledge and skills from nominally different subjects as easily as the engineering system seems to. Degree programmes that are nominally interdisciplinary are also being accredited and therefore defined, in the majority, by engineering bodies. This leaves engineering with significant control over the interdisciplinary domain between architecture and engineering, rather than it being an equal partnership.

CONCLUSIONS

Due to the increasing importance of developing interdisciplinary built-environment professionals there is a clear need for both architecture and engineering professional bodies to discuss and reflect on the apparent overlaps between the academic criteria required for chartership in either profession. It is clear that the engineering professional bodies do recognise the need for a more diverse set of professional skills than just mathematical and scientific knowledge and have adopted a much larger emphasis on design projects and professional skills, paving the way for them to lead construction projects. This, and the increase in the number of degrees that nominally offer components in both architecture and engineering, which are principally validated by engineering bodies, could be viewed as a threat to architecture both as a field of study and as a profession.

It is however very unlikely that, given the increasing complexity of designing our built-environment, the industry will return to having one profession that undertakes all design activities. There is a wealth of knowledge that architectural education has built up in supporting the development of highly creative designers, dealing with unquantifiable problems and critically selecting appropriate methodologies in research and design, which is greatly needed in industry. The architectural and engineering professional bodies need to work together in recognising the commonalities and specialisms of two education systems. They need to respect and use each other’s expertise to support and regulate education standards to ensure production of the high quality interdisciplinary professionals the industry needs.
REFERENCES


CIBSE, 2015b. CIBSE Accredited for CEng [online] Available at http://www.cibse.org/membership/accredited-courses/list-of-accredited-courses/accredited-for-ceng [Accessed 03/05/2015].


Nurse, P., 2014. Ensuring a Successful UK Research Endeavour, A Review of the UK Research Councils,
Department for Business Innovation and Skills.
A combined approach to engineering and architectural education

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ABSTRACT
The majority of students starting an engineering degree in the UK have studied mathematics and one or more of the science subjects with their knowledge assessed through closed book examination. They have little or no experience in applying the subject material to a project brief and, it is this application, mixed with many other considerations, that translates the understanding of science into engineering. Engineering and architecture are both design disciplines so why do we teach them so differently?

Our four year integrated Masters programme in Civil Engineering and Architecture is aimed at those who wish to design structures; the core elements of the programme being Structure, Material and Place. This programme shares its first two years with our other civil engineering programmes. It was apparent that our design curriculum (across all civil engineering programmes) specified many of the expected key design skills but that it was not producing graduates who were agile design thinkers. During the last three academic years, strategic investments have been made to improve our design curriculum, encourage design thinking within our students (and staff) and to foster a greater design culture within the Faculty. This paper will describe the rationale for the development of the curriculum and some of the issues encountered in its implementation with reference to recent student outputs.

INTRODUCTION
The Faculty of Engineering and the Environment supports a wide range of engineering programmes offered at undergraduate level from civil, mechanical, aero and astronautics and ship science to acoustical, environmental science and audiology. Research is focussed on groups that comprise the sub-disciplines commonly associated with these programmes. The Faculty is recognised internationally for its research across all the subjects and, was assessed under General Engineering (Unit of Assessment 15) in the 2014 Research Evaluation Framework (REF). As a research intensive Faculty, all 193 eligible academic staff were submitted and results from the REF confirmed the Faculty’s research as being the most powerful in General Engineering in the UK. Power is defined as the assessed quality and impact multiplied by the number of academic staff submitted. Additionally, the Faculty provided the most powerful submission to the REF from any single institution in the UK, in any engineering unit of assessment. Many of the investments and curriculum developments described will not be viewed as innovative when compared to architectural or other design
focused educational programmes. However, a significant shift in emphasis in the mapping of primary educational objectives at undergraduate level towards integrated design and redirecting engineering laboratory areas away from research use only is highly significant, particularly in the context of the attitudes and behaviours associated with a research focussed community. The changes were necessary to meet the strategic goal of providing world class education in a research led environment in which new knowledge is being created. Careful planning and management of resources was needed to achieve this goal within existing and available infrastructure and resource restraints and they are now providing tangible improvements and outputs that are novel to civil engineering education.

This paper focuses primarily on the development of the MEng Civil Engineering and Architecture undergraduate degree, Faculty of Engineering and the Environment, University of Southampton, the specific investments made during the past three academic years and their relationship and influence on our core MEng Civil Engineering programme. These are described through the illustration of recent projects produced by students enrolled on the programme.

PROGRAMME CONTEXT AND STRUCTURE

In 2009-10, the University reorganised into a new Faculty structure with eight Faculties from the previous structure of three “super-Faculties” and twenty or so Schools. The new Faculty of Engineering and the Environment was formed around the core engineering programmes and Schools of Engineering Science: aero and astronautics, mechanical engineering, ship science, The Institute of Sound and Vibration Research and Civil Engineering and Environmental Science. For administrative purposes, the faculty is divided into four similarly sized academic units of Civil, Maritime and Environmental Engineering and Sciences, Engineering Sciences, Aeronautical Astronautical and Computational Engineering, and The Institute of Sound and Vibration Research.

In 2012-13, taking advantage of the new Faculty structure and the synergies between disciplines that it opened up, the teaching of Year 1 was reorganised so as to create cross-Faculty modules delivered over the full academic year. Civil Engineering programmes participate in three of the new modules: FEEG1002 Mechanics, Structures and Materials, FEEG1003 Thermofluids and MATH1054 Mathematics for Engineers. The remainder of the Year 1 programme comprises an amended module CENV1023 Construction Design and Materials with a substantially increased materials science and design content, and a new module CENV1025 Civil and Environmental Engineering Fundamentals. The latter contains basic chemistry and geology for engineers, as before, but with the addition of computer programming, not previously covered in the first year.
Overall, the aim of these changes was to give students access to new skills in design and computing whilst not decreasing the content and intellectual challenge of their core engineering science activities. From 2012-13, requirements for progression were strengthened by making all modules in Year 1 Core subjects. Thus, the module pass mark of 40% must be achieved in all modules. (Previously this was only true for Mechanics, Structures, Geology for Engineers and Hydraulics modules). For all students entering the course from 2012-13 this limits the referrals that they may take on failure of a module to 30 credits in any one year (previously, there was no limit). The development of the Year 1 modules delivered across the full academic year removed the need for Semester 1 examinations and in their place an intensive two-week design workshop is undertaken that allows students to gain knowledge and skills in design by tackling a range of problems, culminating in a design project that runs through semester 2. Design communication through hand sketching, diagraming, technical drawing, modeling (physical and CAD) and prototyping is taught as an essential part of the design process as well as for final communication of output.

INCEPTION AND DEVELOPMENT OF THE CIVIL ENGINEERING AND ARCHITECTURE PROGRAMME

The Civil Engineering and Architecture programme was established in 2003 to be a headline programme within Civil Engineering and was targeted to attract high achieving students, particularly those who were design focused, or those who wished to have broad design skills. It was considered that the addition of architectural education content would broaden and enhance the core civil engineering education. There were initial discussions with Portsmouth University, School of Architecture to support the architectural aspects and their integration into the programme. This did not go forward, and a team of three/four visiting architects taught the architectural modules – no architects were permanent members of staff.

The programme is a four-year full time integrated Masters undergraduate Honours degree accredited by the Joint Board of Moderators (JBM). Students graduate with an MEng. This qualification offers the fastest recognised route to becoming a Chartered Engineer. Entry subjects are A-level Mathematics and an A-level in another science subject from Physics, Chemistry, Biology, Geography, Geology, Further Mathematics. The third A-level subject is flexible but it cannot be General Studies, Critical Thinking or Use of Mathematics. Current grade entry requirements are A*A*. Students typically have not previously carried out significant project based work. The programme was titled Civil Engineering with Architecture when first established. However, the programme evolved and was retitled Civil Engineering and Architecture with a substantial design component being common to the educational criteria specified by the JBM and ARB. During 2007 and 2011 a number of students successfully applied to the ARB for Part I accreditation through interview. As a result, in 2011 consideration was given to making an application to the ARB to formally accredit the programme. However, changes to the eligibility criteria resulted in applicants from the programme being barred from ARB Part 1 by interview because it could not be demonstrated that it had sufficient architectural education by virtue of its JBM accreditation. This resulted in a reflection on the future direction of the course. This coincided with the appointment of an architect as a full time Faculty member to oversee and strengthen design based education across the Faculty and estate and technical support investments to improve student design activities across the Faculty generally.
The three following key strategic decisions were made:

- The design curriculum within the Civil Engineering programme would be supported to the same extent as the Civil Engineering and Architecture (CE&A) programme – inheriting the momentum from the CE&A programme.
- The ‘additional’ CE&A modules within Years I and II would be removed so that the programmes had equal credit weighting – Years I and II would be the same for all Civil Engineering programmes.
- The CE&A programme would focus to a much greater extent on structural design.

THE BROADER FACULTY INVESTMENTS IN DESIGN

A number of strategic investments have been made by the Faculty to improve design teaching and reputation since 2011 to date and include:

- Appointment of new members of staff; Faculty Director of Design Education, Senior Experimental Officer (to lead on design for manufacture), Teaching Fellow to lead design development in mechanical sciences and three additional student facing technicians to run new studio/workshops.
- Curriculum development with a significantly increased design and manufacture focus.
- The realisation of three 80 seat design studios and associated design workshops.
- Significant investment in an Engineering Design and Manufacture Centre (CNC machinery, additive manufacturing, laser and water cutters).
- The realisation of the Faculty Design Show (including establishing www.uosdesign.org, which acts as the Design Show catalogue and provides a future framework for communication student design activity) and the general increased focus/communication of design activity across the Faculty.

Significant investments in resource and curriculum have realised tangible design impacts. However, the greatest impact has been the development of a design culture (Figure 2). Although much harder to define as it involves intangible elements such as pro-activeness, ambition, collective momentum and identity.
A decision was made to make all design activities project based. This addresses the key objective to strengthen the focus, structure and clarity of our design curriculum and to increase its meaning and rigour through the development of challenging outward looking project briefs that allow for unique solutions to be developed. These activities should encourage diversity and experimentation. A further critical development was to move assessment away from the individual numerical marking of multiple project components to the assessment of design as an integrated solution, fundamentally focused around core design attributes of innovation, process, communication and impact. The teaching impact objective provided a link to the REF Research Impact Statements.

To further support the design process, events such as interim project reviews using external practitioners, presentations and an end of year Faculty Design Show have all been implemented to fuel positive and competitive participation and increase our student’s exposure to a wide range of audiences.

**DESIGN MODULES**

The following is a summary of the core design modules across the four years of the design curriculum:

**Year 1**

CENV1023 Construction, Design & Materials, provides a broad introduction to the ‘design process’. A range of design skills including diagraming, hand sketching, modelling (physical and CAD) engineering drawing, manufacturing, as well as personal skills of observation, analysis, communication, and innovation are taught through their application within design and prototyping exercises. It is taught in parallel with adjacent introductory engineering science modules and specifically draws upon structural and material behaviours. Students are prepared for the Constructionarium (a residential field course www.constructionarium.co.uk) through completion of a series of tasks including construction method statements, temporary works design (formwork etc) and surveying and setting-out methods. The Constructionarium forms a core part of our civil engineering programme and an underpinning context to later modules on structural analysis and design, construction management and engineering economics.

**Year 2**

CENV2028 Design 2 provides students with the opportunity, working in groups between 4 and 5, to design a temporary structure for a site in the Southampton area. They are expected to utilise and further develop the skills and abilities introduced during Year 1. The module builds upon the critically reflective and competitive design environment initiated within Year 1 and offers the opportunity for a ‘winning’ design, as judged by a professional panel, to be developed further and built at full scale for the opening of the Faculty Design Show.

The completion of Part 2 marks the end of the common design threads that are shared across all civil engineering programmes. Part 3 and 4 of the Civil Engineering and Architecture programme is predominantly design project based (66%) delivered through both individual and group project work.

**Year 3**

CENV3062 Architecture 3 requires students to demonstrate a greater understanding of the design process, the application of relevant engineering skills and a maturity of judgment. Projects start at the conceptual stage but an emphasis is placed on detailed design,
aimed at instilling the importance of refining initial design proposals and the application of specific engineering skills and analysis. CENV3062 Architecture 3 is a triple module (45 credits, rather than 15 credits) and therefore provides the required time for students to develop individual design directions and a resultant ownership of their work.

**Year 4**  
CENV6159 Architectural Group Design Project is run over the first semester and requires students to develop and demonstrate a high degree of design ability within the context
of a brief with input from industry sponsors and/or university research. The combined experience and learning gained throughout the Year 1, 2 and 3 modules should be demonstrated. CENV6160 Architectural Engineering Project is a final semester individual design project providing students the opportunity to realise a design solution to a highly technical level that demonstrates the breadth and extent of their abilities.

The following project examples provide a selected overview of recent student project outputs that begin to demonstrate the impact of the recent investments in design.

This traversing structure (Figure 3) has been designed to span between a column and an adjacent wall. Intentionally sculptural in form, the structure uses the bending characteristics and the associated lateral forces generated by layered plywood struts to retain the structure between the existing built elements. Threaded steel bars connect the struts and allow for adjustment.

This lookout structure (Figure 4) was designed to sit on top of, and project from, the end of an existing brick wall. A sectional timber element made from Douglas Fir and perforated to reduce its weight, is held in place by a tensioned cord. The dimensions and geometry of the timber sections are informed by standard brick dimensions. A loose stack of engineering bricks counterbalances the cantilever of the timber through frictional forces greater than the tension forces in the cord and includes a factor of safety for the overall structural system.

This traversing structure (Figure 5) comprises three sections and has been designed to span between two handrails and to avoid obstructing the existing access route below. Two laminated flared MDF panels provide lateral stability, one rigidly connects to the handrail at a fixed angle, the other rests and pivots on the handrail requiring the central plywood section to bend under the weight of the panel; this results in the overall structural form.

These ascending structures (Figure 9) have been designed to slot into the vertical rebates in a wall and be capable of installation at differing heights. The structures act as levers to create friction forces between the structure and the internal sides of the wall rebates. Constructed from laminated laser cut MDF they are hollowed out internally and have concealed steel weights to create the required friction forces.

This structure (Figure 11 and 12) has been designed and built by a group of second year civil engineering students as part of their design curriculum. The project brief asked for the
design of a unique temporary structure for a site adjacent to the medieval walls located towards the southern end of Southampton. The structure was to provide a focal point for visitors and act as a potential catalyst for cultural activities in the area. This structure fits around and masks the view of an unsightly existing footbridge whilst also acting as a celebratory gateway for pedestrians passing under and over the bridge.

The concept design considered a range of factors; the local site characteristics and its surrounding environment, the temporary nature of the structure, form, proportion and the user experience, differing material characteristics and construction process. The production of drawings and scale models and the use of calculation resolved the design through an iterative team working process. The detailed design was developed with support from a professional consultant team and further resolved the structural stability, member sizes, connection details and construction tolerances. The final structure was constructed with the assistance of a local contractor using locally sourced rough sawn Douglas Fir, proprietary galvanised fixings and an ultra-saturated water based red wood stain.
“Having the opportunity to work as a team and alongside professional consultants to develop our own unique design solution, and then to be involved in the full scale construction of our design has been a challenging and rewarding process. We are all very proud of our structure.”

Project student team: Aiden Brown; Part 2 MEng Civil Engineering and Architecture, Rosalynde Burchell, Sally Pickard, Jared Tiller; Part 2 MEng Civil Engineering.

LOUVERED SHELL, HIGH STREET, SOUTHAMPTON

This project (Figure 13) proposes a cafe and restaurant unit to the south of the archaeological excavations, the utilisation of the existing vault and a wide span structure to protect the excavations from the effects of weathering. A louvered steel cladding unites the elements.

The area to the south of the vaults is excavated to create a submerged structural box housing a two storey cafe and restaurant. Double height volumes are used to create visual linkages between street and basements levels, utilise daylight and create unique and engaging spaces. Sheet piling is installed around the perimeter of the site with reinforced...
Concrete walls cast in-situ to form the internal layout and provide stability for the roof and cladding structures.

Structural analysis carried out to ascertain the likely performance of the existing vault structure suggested that additional loading would be detrimental to its integrity. The proposed concrete slab above and pedestrian walkways are hung from the primary roof beams to avoid additional load being placed on the vault.

**MULTI-LEVEL PLAZA HIGH STREET, SOUTHAMPTON**

This project (Figure 14, 15 and 16) proposes the extension of the public realm to provide improved access to the basement level archaeological excavations/vaults and to provide protection against the effects of weathering.

The area to the south of the vaults is excavated to create stepped access descending down to basement level, a plateau midway down breaks down the vertical travel distance.
and provides an area for external seating in the summer; the steps are orientated south to also act as seating. Sheet piling forms the edge of the area to be excavated and extends around the existing excavations to stabilise the boundaries and reduce identified water ingress issues.

A steel framed canopy structure spans above the existing exposed archaeological excavations, its column loads transfer to the proposed retaining structure and the efficiency of the beam grid has been refined to reduce weight and aid construction. Access onto the southern section of the canopy extends the possibility for the public to experience of the site.

**CANOPY, QUILTERS VAULT, HIGH STREET, SOUTHAMPTON**

This proposed structural design (Figure 17 and 18) results from the consideration of the building’s street context (scale, proportion and massing), programmatic requirements (access, circulation and function), site characteristics, structural and material performance, and the construction process.

A steel framed canopy primarily designed to enclose the existing medieval structures and shelter them from the effects of weathering. The structure also aims to increase public interest and cultural focus towards these important archaeological structures within the city wide context.

The external shell of the building staggers in plan and steps in height to establish an exterior mass suitable to its streetscape and to create inspiring volumes internally. These formal shifts provide locations for an entrance and exit and allow for significant glazed openings that maximise the use of natural light. The pitched roof effectively drains rainwater and further breaks down the mass of the building.

The complexity of the site ground model dominated the location and development of the inclined struts that provide vertical support to the roof structure and provide overall lateral stability. Trusses and bracing elements support spans, provide stiffness and characterise the appearance of the canopy structure. Piles, ground beams, thrust blocks and spanning slabs are used to provide stable foundations that avoid placing load on the existing structures during the lifetime of the building.
The building is clad with horizontal louvers that allow air to freely flow through and for the support structure to be seen as integral to the appearance of the building. The facades are further animated when illuminated at night time. The elevations are hung and stop short the surrounding street surface to emphasise the insertion of a modern structure and the retention of the historic fabric.

**CANUTE’S PALACE RESTAURANT, CANUTE’S PALACE, PORTERS LANE, SOUTHAMPTON**

A steel framed and timber clad building designed to partially sit within the footprint of Canute’s Palace (Figure 19 and 20).

An evaluation of the site suggested that building solely within the footprint of the existing building would not support an economically sustainable restaurant and it was not possible to extend using the existing site levels. The floor level of the proposed building is raised (to retain public access to the archaeological remains) and ramped access utilises the existing masonry shell as the main entrance and to locate the kitchens and associated services. The dining area sits adjacent to the northern elevation of the existing structure and faces Town Quay Park. This arrangement results in the north wall of Canute’s Palace being encompassed within the proposed building, acting as a visual break between the front and back-of-house and emphasising the relationship between new and old.

The proposed building extends east towards High Street to achieve a street frontage, maximise park views towards the north, and form a visual boundary along the southern park boundary. A braced steel frame supports this long, relatively narrow form, a column grid and its cross bracing is left visible and proportioned to realise an efficient structure, span underground archaeology and coordinate with functional requirements. The structure is portilised below its ground floor to avoid visually detracting from the view of the enclosed historic wall and removable screw pile foundations transmit the load to more competent strata and avoid placing load on archaeological features.

This project has been developed and communicated using a range of design methods; sketching, technical drawing (Autodesk AutoCad), three dimensional computer modelling (Autodesk Revit), physical model making, hand calculation and computational analysis (LUSAS) to provide a fully resolved structural solution.
CONCLUSION

It is important to recognise that the investments described within this paper are recent (within the last three academic years) and only represent the start of a much wider strategic plan to improve the design abilities of our engineering graduates. As such, the conclusions and reflections are made against limited data. However, it is possible to identify positive emerging trends.

• Students are becoming increasingly independent and proactive in finding solutions. They develop new knowledge and draw linkages between the content of all their taught modules within the context of addressing their design briefs. Craft, skill and judgement of the students is now more significant.

• It is apparent that students now have a greater ability to critically discuss their work. There has been a shift from a predominantly defensive stance when confronted by critical review towards more productive engagement that assesses the advantages and disadvantages of their proposed design solutions.

• Design has moved away from a final proposal to illustrate the aesthetics of an idea towards an understanding that design requires an iterative, critically reflective process and the delivery of a suite of high quality information from which others can understand the proposal.

• The importance of students feeling integral to a programme with a clear identity is becoming more apparent. The increased design opportunities offered within all civil engineering programmes offer ‘ownership’ of unique designed outputs.

• To support the uplift in design ambition, the development of appropriate work space and provision of dedicated technical support has required extensive re-purposing of estate. This was initially met with resistance amongst the academic community but which is now seen as essential to the broader development of integrating design across all undergraduate programmes. Transformative events such as the inaugural Faculty Design Show have been essential in demonstrating to the broader academic community the benefits and uplift in educational attainment made possible by these changes.
Nurturing the citizen designer: Re-defining participatory frameworks for professional re-alignments

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ABSTRACT
There are two clear conditions, amongst a host of others, affecting the prevailing state of architecture in the Indian context. At one end is the growing skew of professional attention around metropolitan and larger urban domains while at the other, is the disciplinary fixation in architectural schools on the glamour of the iconic as against the needs of the everyday. While architectural practice in India so far has offered negligible service to the vast majority of non-urban settings, in many ways, architectural design education programs too have remained disconnected with current flows of society and time. Let alone performing leadership and critical roles for practice, architectural education has struggled to address changing conditions of societal and physical settings.

Today, our increasing global connectedness is seen to effect widespread aspiration-driven demands on the professional expertise of architecture and related disciplines. In the race towards accomplishing our global dreams, the alienation of architectural practice, research and academia from existential social realities seem vividly deeper. While ‘stakeholder engagement’ has been a parallel mantra to all mega-development initiatives, the reality of participation increasingly revolves around professional super-specialists from all over the world.

Beyond the hype of neo-liberal opportunism and political rhetoric, could there be a re-alignment of our profession and academia towards addressing social realities and emerging contextual complexities through a re-defined framework of participatory engagement and co-creation of built environments? Specific to our conditions of professional (and academic) skew, this question formed the basis for a sustained inquiry towards re-visiting prevailing processes of academic exploration and practice. Using the rich experience of a prolonged community based engagement in remote tribal regions over two decades, this paper explores the dynamics of architectural contribution within the comparatively less discussed space of institutional practice as the intersection of practice, pedagogy and research... towards an alternative, immersive and grounded approach of nurturing citizen designers as custodians for a more collaborative, sustainable path for future change.

INTRODUCTION
India’s requirements of shelter, infrastructure, work, business, recreation are multi-dimensional and diverse. Both, in terms of distribution and adequacy of
service, our prevailing professional reach is but a fraction of what our nation asks for. In this situation, product driven solutions attempted through conventional modes of architectural production as an outcome of practice-based engagements and correspondingly nurtured as pedagogic directions in architectural schools can but only address a very limited proportion of the built environment demand spectrum across the country. The productive capacity of an average firm and associated expertise networks that we have been so far familiar with using conventional mode of production through a linear progression of individual projects from conceptualization to realization cannot match the exponential demands of the building sector. Moreover, such production trajectories in the private sector have focused primarily on the relatively affluent minority in metropolitan cities whose financial prowess has attracted and shaped the overall profile and delivery mechanisms of our professional service.

Given the prevailing shortfall of practicing architects for the present magnitude of our urban population and even with the most optimistic speculation of hyperactive growth in the number of architectural schools and serving professionals, a healthy ratio of architects to population served in this country is almost unimaginable. Additionally, three and a half decades from now, around 2050, our country would be only halfway towards an urban society. Recent trends suggest that the convenient assumption of rural architecture primarily comprising of “self-build” units and hence offering negligible roles for the professional architect is dated and evasive of the realities of today. To the contrary, the pace of change in rural areas, especially in architectural shifts from the local vernacular to the aspired urban is significant across the breadth of the country (Dasgupta, 2008). If demands from this sector of our population are accounted and added to projected urban demands, we have at our hand a bewildering scenario of professional need that is not only beyond immediate comprehension, but also well beyond any possibility of coverage within a plausible time frame of the future. It is evident that a fresh trajectory of professional engagement as well as academic focus, in consonance with the unique and complex societal conditions of our part of the world, is necessary.

This new trajectory (in addition to, and not in substitution of, the prevailing range of diverse engagement paths followed by the profession) needs to address not only the seemingly incomprehensible dimension of quantum but more so, to the parallel and much neglected questions of equity, affordability, identity and sustainability that plague our academic and professional output. Since our Independence in 1947, the twin modes of architectural practice and education have concurrently progressed over the years through periodic waves of creative alignments – first with the Modern Movement and (simultaneously with) Revivalist surges in our search for a national identity of a free nation, then with our experiments with Neo-vernacular and Critical Regionalism, thereafter through sporadic forays with post-industrial Post-modernism and De-construction, finally embracing the world of neo-liberal, techno-service-systems based, globally universal architecture. While the bulk of architectural production revolved around these formal movements of architectural explorations, there have been scattered, albeit concerted efforts in alternative terrains of engagement especially for the less catered majority of non-urban and marginalized population of the nation. Thus at one end, the iconic figures of Le Corbusier, Louis Kahn and their progeny of Modern Masters paved the way for the Indian entry into the world of contemporary designer architecture,......at the other, somewhat quieter practices of Laurie Baker and bottom-up initiatives like Development Alternatives, Costford, Barefoot College, Hunnarshala, Lok Jumbish and DPEP programs along with a handful of others have been striving to find relevant answers to ever-growing questions of architectural production and meaningful delivery of expert services. All along, the world of practice has progressively
remained the dominant leader in shaping the disciplinary discourse with academic programs submissively following the lead and responding with corresponding directions of applied knowledge necessary for such a practice-driven environment. Neither practice nor academia have nurtured a sustained platform for focused exchange on critical discourses related to either, the provision of professional architectural service or, disciplinary queries pertaining to academic inquiry raised in each passing time. It is in this vacuum of collective interaction that the business as usual mode of architectural involvement drifted through the dominant, perceived demands of the profession from the visible, resourceful, urban sector, both through state-driven agendas as well as private enterprise. In connection with his recently curated exhaustive work on the State of Architecture in India, Rahul Mehrotra, noted educator, practicing architect and urban designer says:

“The world changed drastically and rapidly in the 1990s – and we could not as an architectural profession keep pace with it – unable to understand what had hit us. Rather than developing newer languages and idioms, and tools to assess and read the new architectural turns, we often resorted to a denial of the shape of things, to a rhetoric of rejection, and misplaced nostalgia. Politics has become ever more complex, and architects from once being agents of social and aesthetic revolutions, now maintain a technocratic attitude, where you fine-tune your skills, but avoid addressing the very environment [social and cultural] that you ironically depend on for your daily bread and butter!”

Academic curricula and more so, design pedagogy, have had dormant, satiated existences for quite some time consistently focusing on the extra-ordinary and iconic rather than on everyday realities (Dasgupta, 2012c). Rarely has there been a decisive urge to question our academic path and rather than allowing for the development of significant, differentiated trajectories of inquiry and exploration in consonance with our societal diversities, the super-imposition of a standardized, national agenda for architectural education through a mandated, central body has further frozen the possibility of architectural experimentation, critical debate and creative departures from the common denominator of prescriptive knowledge frameworks. Another noted architect and thinker in the profession, Prem Chandravarkar comments, “In India architectural education tends to be highly vocational so the architectural profession by and large is not trained to think in theoretical or philosophical terms, and that’s the other thing we sorely need to be - to talk about architecture in general terms.” (Ramachandran, 2015).

Exercises in design studios are conceived as projects with clear beginnings and definitive/expected ends. Here, design explorations around each problem must be taken through a creative journey of conceptualization, development, resolution and representation. Open, wicked exercises are seldom imagined as possible avenues of experimental interrogation and design creation. One of the first departures that the new trajectory envisages is the formulation of an open program rather than a closed project. This shift ensures possibilities of adaptive re-orientation and flexible task articulation with respect to the unfolding dynamics of a transforming setting within which project-based explorations may be situated. The second departure that this trajectory suggests, lie in the sustained engagement of the creative team with a given contextual setting over an undefined, prolonged period of time. This by itself stands apart from time-bound, semester problems of academic design studio exercises or project deadlines associated with client based professional service. The possibility of an extended time frame allows for the development of multi-dimensional strategies for modulated engagement in response to the diverse sets of developmental processes that are simultaneously in play for transitional situations
within strongly differentiated social conditions such as ours. As is evident, such an extended duration of architectural engagement does not ensure either consistency of human resource within the creative team, nor does it allow formal parameters of academic progression and/or conventionally drawn project related Terms of Reference. What it does permit however, is a variable set of experienced and fresh minds, joining hands for the time they can be together contributing to the program in response to, or in association with the issues of developmental need perceived during their period of engagement and in alignment with stated visions and objectives of the program. Students, researchers, faculty, designers, domain experts join in, move on and re-join as and when intent, opportunity and occasion allow while the program continues to engage with the changing scenario of the setting in which it is located. The third departure is in the creation of a process-driven collective enterprise against a product-oriented design engagement. The central aspect of this shift is in the positioning of the designer as a participant-actor of the community with whom the design program progresses. It is in the belief that co-development of future conditions of building and living as a collective human endeavor as against the delivery of a specialized service or product is where the foundation of a grounded, intimate and collaborative process of creation gets embedded. This process embraces multiple levels of demands and aspirations as well as examines the methodological dimensions of the production of built environment that are both internal to the community as well as that harnessed from the world around. Within the larger sets of transformative forces in operation, this process-centric approach to the building of architectural knowledge (rather than the architectural unit) as relevant for the community’s future trajectories of change, underlines the most important shift in this alternative path of architectural engagement.

EXPERIMENT

Over the last two decades, across the wide expanse of the Himalayan belt in northern India, the transformation of erstwhile vernacular built environments has been a growing phenomenon. The implications of such a pattern of change specific to this region is significant, given the fragile conditions of the eco-system on one hand and the prevailing trajectories of development trends in these areas, on the other. Vernacular construction with its pragmatic approach, locally oriented systems, embedded symbolism and inherent constraints, generates a distinctive built environment reflective of regional and local identity. But the growing aspiration for urban buildings, difficulty in procuring traditional materials and rising labor costs for vernacular construction, accompanied by demands of new building types, increased road connectivity, readily available, cheap, urban materials among other factors, have prompted an increasing pace of transition towards modern construction. The loss of the vernacular built quality is therefore in essence the redundancy of the systems that had led to its production. Transformations in the economic and cultural environment that had promoted these systems would inevitably lead to creation of a new order. The issue of deliberation is about the nature of the emerging order and its impact on the larger level.

This paper highlights the discourse of change in vernacular architecture of the western Himalayas and connected methods/processes of constructional technologies tracked over a period of fifteen years through empirical studies and long term evaluation. The arena of such explorations is concentrated on three remote tribal settlements located within two districts of the state of Himachal Pradesh. Specifically, this part dwells in the first instance, upon the parameters governing the above mentioned directions of change leading to the gradual erosion of prevailing vernacular processes that constituted and typified settlement patterns and further goes on to discuss possibilities of multi-level, inter-disciplinary, collaborative prospects through a mechanism of sustained institutional engagement at
varying levels of decision making towards a sustainable future ahead. Out of the three case villages, Bharmour in district Chamba has emerged from an erstwhile pastoral, nomadic pattern of life to an important religious destination, growing rapidly to engulf other surrounding hamlets towards the formation of a rudimentary urban center (Sarkar, 2008). The other two settlements, Kalpa and Sangla form a twin cluster of complimentary villages in the district of Kinnaur with unique cultural and social characteristics within spectacular scenic settings. All three settlements, positioned above 2300m from mean sea level are qualified also by a local economy with a high degree of horticulture base as well as a rapidly growing rural tourism sector. While Kalpa-Sangla attracts both national and international tourists who visit these locations as getaways or adventure tourism spots, Bharmour caters to an increasing population of domestic, religious tourists and pilgrims. All three villages reveal evolved processes of the vernacular and strong forces of change affecting them today. The following part describes the experimental engagement that has incrementally taken shape with glimpses of field observations and connected findings on salient issues along with essential features of a possible way forward through multi-level dialogue, strategy formulations and design guidance for future directions of change.

PHASES OF ENGAGEMENT

The Himalayan Action Research Program (HARP) had its genesis in a faculty-led research initiative, called the Related Studies Program located within the TVB School of Habitat Studies in Delhi. With an initial academic objective of developing an empirical, archival data base on indigenous architectural response to diverse climatic zones in this country and confronting the vexed question of an architect’s role beyond the city, the program sustained its research initiative through a decade long engagement in the mentioned
study areas. Over 180 students and three faculty members with architecture, landscape and construction specializations apart from resource experts from the fields of economics, architectural conservation, urban design, building services, energy sciences and environmental planning converged at various points of time to actively engage with the selected tribal villages. Three distinct phases of engagement have been summarized below:

**Phase-I** involved fieldwork in all three villages, which initially comprised of extensive on-site documentation and survey of physical characteristics of the place through a series of mapping tasks across various scales of representation (Dasgupta, 2011a). The physical survey was accompanied by related studies of livelihood, life-style and occupancy patterns for a deeper exploration of tribal communities in harsh mountainous terrains. An analytical understanding of the physical characteristics of these settlements in relationship to the characteristics of the locale as well as socio-economic and cultural profiles was generated for each of the study cases as a precursor to further discussion and subsequent engagement. This period of survey, study and analysis stretched over a period of 2-4 years for each settlement.

**Phase-II** of the program involved a dialogue with the state government through the Secretariat and specifically with the Departments of Urban Development, Environment, Tourism and Tribal Welfare. Such a dialogue involved the exchange of inner perceptions of the state with the HARP design and research team on critical issues and findings of the survey and initiated study. The documentation of physical resources and their present status for each settlement served the foundation for debates across discussion meetings. The Chief Secretary of the Government of Himachal Pradesh called for successive meetings attended by Secretaries of individual departments including the Public Works Department; Environment & Forests; Finance; Tribal Welfare; Language, Art & Culture, Transportation and Tourism as well as, through live video conferencing with district administration, block/panchayat level officers and representatives of local communities as respondents to a series of presentations made by the research-design group. One of the clear outcomes of the discussion was the perceived lack of creative and technical inputs that was imperative for directing growth and transformation of the villages through a well coordinated policy and connected action programs. The felt need of a prolonged community-driven engagement with the processes of change in selected areas and multi-tiered involvement of diverse expert domains was articulated as a vital aspect of the possible path ahead. At this stage, it is important to note that this mountainous state of Himachal Pradesh is still 95% rural and has had limited policy thrust towards planning and design strategies for rural transformations. The meetings at the Secretariat resulted in a formal MoU and Agreement between the Government of Himachal Pradesh and the School of Planning and Architecture, Delhi to conduct an applied research program using a modest grant for the selected three tribal villages towards formulation of guidelines for development and recommendations for further action.

**Phase-III** of the Himalayan Action Research Program included re-visits to each of the three case villages and re-engaging with the local community at varying levels of dialogue with a focused agenda of exploring possibilities of contribution to sustainable development and change. Recognizing the fast pace of transformations that all three village cases had undergone during the intermittent years after the conclusion of the basic surveys in Phase-I, the study team, along with district officials and village representatives embarked upon a bottom-up, reality driven, collective agenda for directed change. Fresh assessment studies were conducted including re-surveys of physical characteristics (built form, movement system, functional distribution, construction strategies, etc.) as an extension of the earlier
study as well as sample surveys of community responses towards a diverse range of issues and potentials that could be identified from within (Dasgupta, 2011a). Using the example of the twin settlement group of Kalpa-Sangla in district Kinnaur, a brief discussion of the salient factors and expressions of built form transformations is presented below:

TOURISM INDUCED CHANGE

Today’s Kalpa-Sangla offers a picture of a rapidly emerging sporadic assembly of urban building types dotting its once pristine natural setting (Figure 2). The spurt of domestic and foreign tourism that this region is attracting has been one of the principal factors contributing to the fast changing scenario of a transformed aesthetic and built environment of this place. The advent of tourism has ushered in the production of new building types like multi-storied building stack amidst precious orchard areas, linear blocks along movement paths, clustered grouping and enclosed spaces in flatter areas, etc. These forms have emerged in the settlement fabric as trend-setting demonstrations influencing possible directions for other enterprises to follow.

TECHNOLOGY INDUCED CHANGE

A paradigm shift in the availability and use of locally procured building materials and technology towards modern urban materials and systems is generating a sweeping transformation of built characteristics (Figures 3, 4, 5) in Kalpa-Sangla and the state in general (Dasgupta, 2011a). The gradual erosion of climate sensitive past techniques of timber and stone-based construction, specific to this region including some invaluable practices of earthquake resistant construction systems are evident. This is giving way to energy intensive, conventional urban technologies using brick and cement masonry in reinforced cement concrete (RCC) framed structures and roofing systems. Most of the new buildings in the settlement (about 86%) are constructed using RCC along with brick and cement, due to its low maintenance, speed of construction and growing availability of materials and skill. Additionally, skilled artisans in RCC construction activity from the states of Bihar and Uttar Pradesh are entering the construction sector with rising demand for such modern techniques, steadily pushing local artisans gifted with the knowledge of the vernacular to the margins.

ASPIRATION INDUCED CHANGE

Relative affluence brought about with increased revenues from horticulture and monetary gains due to land based compensation for upcoming Hydro-electric power projects in the region have started nurturing new life-styles and alternative avenues of engagement with corresponding expressions across different social segments of Kalpa-Sangla, especially among the youth. Proliferation of personal motorized means of transport, mobile connectivity and satellite (dish) TV amongst a host of other contemporary technologies is ushering in an unexpected direction of socio-cultural and material changes throughout this settlement. Increased connectivity and economic prosperity have altered the way of living, particularly with strong influences from the urban world as reflected through built expressions and interior spaces (Figure 6).

COLLABORATIVE STRATEGIES

Reflecting on the findings and observations of the assessment study on the prevailing trends of change from each of the settlement cases, a summary of directions of such change becomes the starting point of discussing ongoing and future partnerships between external expertise and resident communities. The following table captures the generic levels of change (Figures 3, 4, 5) in the domain of the built environment, as observed across
all three settlements at different scales of correspondence: The set of transformation trends (above) suggests at one level an increasingly unsustainable trajectory of building in these regions, while offering the potential for design and technological interface appropriate for such locations. In the ensuing future ahead, the settlements of Kalpa and Sangla are envisioned to embark upon a model developmental path that proposes a balanced growth of new activities without endangering ecological processes that nurture this region, while upholding cultural identity and vernacular
expression. Such an effort has been initiated through combined explorations of possible prospects in community meetings. Individual members as well as groups of the local community are engaged with the HARP team to discuss, conceptualize and propose projects at varying scales in different parts of the settlement. Strategic inputs by way of design guidelines for future development (formulated specifically for each settlement) has been created as an outcome of the assessment studies as well as community based meetings on directions for the future (Dasgupta, 2012a). These guidelines, compiled in the
form of reports (Figure 7), specific to different parts and aspects of each settlement have been submitted to the Town and Country Planning Department, Government of Himachal Pradesh for deliberation and action by the State (Dasgupta, 2012b).

A comprehensive list of possible projects spanning across individual buildings to social and physical infrastructure for prioritized implementation with respect to community
needs and funding possibilities have been collectively identified. Individual entrepreneurs with business proposals for new tourism options, domestic residents with ideas of house modifications as also temple trust desiring spot improvements and such others form the diverse group of stake holders from within the settlement and beyond (Figure 8). Over the last few years the HARP team has been engaged in the design of a variety of building and...
area development projects across a range of contextual conditions as potential examples of representative solutions (Figure 9). These projects cover a wide range of requirements from individual residences, guest houses and tourist lodges to village schools, community facilities, spot development, area upgradation, etc. Importantly, the range of design solutions explored by the HARP team along with the community contributes to the overall production of architectural knowledge in addressing new demands like that of rural tourism, recycling and retro-fitting, energy optimization and the like. Also the implementation program presents an option of developing projects under various modes of partnership, such as state and community, NGO and state, citizen and NGO, among others. This multi-level partnership expands funding and implementation alternatives too, since a number of the proposed mission projects could be funded through central or state level schemes from various departments/ministries as also by local groups or individuals as the case may be. The list of projects formulated with the community has been forwarded to the state government for consideration (Dasgupta, 2012b) and a few have found initiation too. Simultaneously, a determined agenda of awareness and exposure to realities of the built and natural environment prevailing in the settlements today along with their connected implications is being put in place through a system of newsletters, manuals and maps in local language, for all members of the community.

Earlier, a state wide endeavor towards universal primary education across 25 villages in four districts of the state gave the opportunity of realizing innovative primary school designs constructed through a partnership between the State Education Department, Village Education Committees, International Funding Agencies and Consultants under the District Primary Education Program (DPEP). Through community based participatory mechanisms at every stage, this project allowed for experiments in vernacular adaptations, exploration of intermediate construction technologies (Figure 12) and cost effective strategies to deliver site specific building solutions in individual village sites (Dasgupta, 2008).

The pressing needs of the community and the settlement as visible from the conducted studies require a cross disciplinary engagement with the community at every level of
decision making. An extension cell of the research-design group is being setup in each of the three villages to enable a multi-disciplinary set of expertise be available for the diverse needs and requirements identified through previous studies. The cell has three clear mandates with respect to its performance within the settlement and resident community—knowledge production, capacity strengthening and outreach. It is seen already that the present community base is a highly evolved repository of traditional knowledge related to responses of built form within natural settings. However, present day demands and technological changes have not found sufficient place in the evolution of the above knowledge base. At the other end, the department of Town and Country Planning and the state Public Works Department have been yet unable to mobilize adequate in-house technical resource especially in hill-area planning and design. At both these levels the cell can play a pro-active role through training programs and workshops on live demonstration projects for enhancement of collective capacity of the resident community as well as state planning agencies. Scientific methods and technical know-how available in the world at large is to be harnessed through appropriate networking mechanisms and strategic outreach initiatives by the cell and contextually reapplied in the settlement fabric. Through time, the extension cell is seen to co-develop necessary inputs and innovative solutions to the emerging problems and issues that each settlement could specifically need to confront.

**REFLECTIONS**

Our engagement with the three tribal villages of Himachal Pradesh over the last two decades has now revealed an array of potentials and challenges for addressing the existing conditions of change in these areas. Possibilities of co-development of technologies through a combined technical interface is of considerable potential especially since the
inherent levels of indigenous knowledge systems and collective wisdom is still visible within the physical and social fabrics of these settlements. Beginning with the “kathkona” system of time-tested earthquake resistant techniques or innovative “dhajji” walling systems to advanced levels of stone masonry and carpentry skills as also climate responsive solutions through design layout and building skin details, the avenues of co-development of reliable, relevant and innovative technological outputs for a sustainable path ahead is of immediate consequence and application. Although local knowledge base and collective wisdom for each of the identified components of the vernacular is immense, applied technologies of today are neither derivative of local conditions nor are they selected with the refined judgment of past choices. It is at this juncture that the collaborative platform of the Himalayan Action Research Program with its extension cells in the field seeks to continue its contribution through a well-articulated, meaningful and responsive agenda of engagement. From scientific survey and documentation methods using GIS and other applications, solar passive techniques of energy optimizations, computer aided tools of climate simulations and technology options, composite walling, roofing, flooring and ceiling systems to policy directives on sustainable planning and waste management, eco-tourism, home-stays and craft based home industries, the spectrum of collective, participatory co-sharing of knowledge and application systems is, at once vast as is imperative. The introductory partnership for technical exchange created at the level of the state between the Government of Himachal Pradesh, School of Planning and Architecture, New Delhi, professional practices and resource experts is a unique, initial venture which is imagined to grow to a more comprehensive, wholesome and vibrant collective of interactive domains of diverse stakeholders for this task.

The challenges emerging from such experience of sustained engagement with communities under transition become important for consideration to the way ahead. These challenges occur at three broad levels. At the village level, aspiration-led demands and prevailing commercial forces significantly add to the pressure of rapid pace of change. The trends of upward economic mobility of a significant cross-section of resident inhabitants have given rise to a variety of internal demands catalyzing a chain of transformations with preference to urban products and life-styles. Non-availability of local material choices has further fuelled this trend corresponding to altered life styles. In addition, the lack of personal time for individual attention to building as a self-help personalized craft has given rise to outsourcing of building activity to contractors and masons not necessarily from the region. At the state level, such an endeavor faces significant challenges firstly, with respect to the dearth of exposure to the range of design and technological applications available for specific situations faced by hill settlements. Secondly, this lack of exposure is sometimes aggravated with an indifferent skepticism from some of the policy and decision makers to the efficacy of application of borrowed/alternative possibilities to problem resolutions. In addition, lack of consistency amongst government departments to sustain a long term explorative path of creative engagement is one of the strongest challenges still being faced by committed consultants of this state and across the country. Finally, the short tenure of Heads of Departments and members of the Secretariat who are vulnerable to be transferred out of their present positions before the end of any determined project becomes an extended area of concern for such kinds of experimental endeavor requiring prolonged support and patronage.

At the level of the research-design group, the difficulty of continued intensity of field involvement and necessary presence at site, especially for such remote Himalayan regions, becomes one of the primary challenges facing such an exercise. This results in a somewhat fragmented or sporadic nature of expert engagement in rural domains where consistent
inputs are all the more imperative. The lack of an evolved institutional and financial mechanism to support cross disciplinary partnership and co-development of technologies is finally one of the more crucial challenges to the development of appropriate design and production tools for the changing rural sector and connected environments.

CONCLUSION

Notwithstanding the above mentioned challenges in negotiating prevailing winds of change in these remote Himalayan regions, the larger cause of sustainable development and connected explorations towards the same needs to be the driving force for any such endeavor. The participatory framework outlined in the above experiment moves beyond the customary stake-holder engagement that most state driven missions for development have mandatorily requisitioned. The need for an evolving, sustained program of participatory engagement at varying levels of dialogue and partnership is imperative for a socially driven agenda of developmental change. In the case of this program, the creative design and research team has been oscillating between the community and the state allowing for a mediatory, facilitating role to be nurtured through a steady building up of a mutually inclusive relationship across both community and state actors. For the community, at the threshold of taking new decisions related to their aspirations and choices of shaping their built environment, the idea of a technical group discussing and associating themselves through knowledge exchange and co-design of their present and future habitat needs, holds relief and promise specially when the possibility of such an interface is seldom attainable in these remote regions. Through sharing of problems and prospects confronted by the community as well as through formal and informal exchanges related to the same, a mutualism of collective enterprise and contribution is built. Community expectations from the HARP team and the program has traversed through looking for specific design and construction advice to their new problems of tourism building types, structural inputs especially for RCC construction, building facades, retrofitting wet spaces and toilets and internal spatial modifications of houses to tourist home-stays. But more importantly, successive interactions have started orienting the collective architectural discourse towards issues apart from solutions, applied knowledge apart from new information, methods apart from products. The dialogue around architectural production commensurate with local needs and larger concerns, rather than the material production of architecture alone is a strong facet of the program taking shape gradually.

The intersection of practice-research-pedagogy that this experiment pursues suggests a move away from the existing, water-tight, knowledge sector domains that we are familiar with. To begin with, the understanding of developmental processes in our societies is by itself a critical pre-requisite, challenging in the process, some of the conventional modes of interpreting or, even by-passing our societal realities. Field based empirical research leading to greater unearthing of prevailing processes of architectural production feeds into the development of a pedagogic and disciplinary approach of addressing issues inherent therein. Far from the design studio, the student (as also the researcher/practitioner/teacher) grows with the program as it unfolds its layered characteristics of developmental change. While the formal curriculum trains them to address varying complexities of individual design tasks delineated by the studio tutor, the student here becomes the initiator of design dialogue related to necessary architectural production. His ways of seeing the issues of built environment through direct contact and connected interactions with the community allows him to construct a role for himself and delineate his contribution for the community and its future. He becomes the citizen designer.

If community capacities are to be strengthened in the shaping of their own habitats,
citizen designers need to play a pivotal role in spearheading such a task. Academic institutions correspondingly therefore need to undertake the responsibility of nurturing such groups of designers who would become instrumental agents of collective, creative action in each community where they find themselves in. Such a movement, where co-creation of human habitation for the future is galvanized through collective enterprise using proactive contributions of the citizen designer needs to spring from the academic world of architecture which, through its central agency of knowledge creation, capacity enhancement, outreach, networking and applied experimentation becomes the ideal venue for this alternative trajectory to unfold and consolidate. Beyond formal firm-based practice domains, the possibility of a new form of ‘institutional practice’ revolving around a collaborative framework of varied domain expertise creatively harnessed through the efforts of citizen designers engaged with co-production of design knowledge in association with the community, offers a fresh way of serving future demands of our unique built environments. Seen from the perspective of the professional world of applied knowledge, this kind of practice that lies at the intersection of research, pedagogy and professional service becomes a relatively new, but much required realignment of disciplinary engagement that connects more substantively and meaningfully to the real dimensions of our kind of society.

REFERENCES


Human computer interaction systems and educational strategies to support design participation

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ABSTRACT

This paper brings together some key issues: How can a computationally-based architectural design application be developed to facilitate design participation, specifically using techniques of human-computer interaction? What is the role of professional architects as facilitators of participation and how can they be educated for this role? What are the implications of design participation as an expression of a wider social and political process of ‘democratisation’?

The term ‘democratisation’ usually refers to the widening of the franchise for active participation in political decision-making compared to decision-making dominated by established elites. Recently the term ‘democratisation’ has also been applied to the widening of access to personal opportunities and to technologies, the latter often in the form of computer based consumer products or services. The impact of such ‘democratisation of technology’ may also have wider social and political significance.

Therefore, what better use for the ‘democratisation of technology’ than the ‘democratisation of architecture’?

Design participation starts with two ideas: First, that the most important aspect of any building is the satisfaction of the people who use that building. Second, if architecture has to balance technical, functional, economic, social and cultural concerns then the people who use the building are best place to determine this balance.

Previously, end-user participation in architectural design may have been considered to be rather ‘idealistic’, because of the lack of tools and methodology to make this a practical reality. The premise of the research presented here is that computational techniques, specifically innovative approaches to human-computer interaction can be used to develop special architectural design tools which can be effectively used by non-professional building users to create viable architecture.

Within the overall theme of design participation there is a very important educational sub-theme. Essentially, the participatory design software must not only provide an opportunity for the building users to express their own design intent, the software must, in ‘very short order’, educate the participants how to make design decisions. Specifically, how to make suitable trade-offs.
between design and performance variables. Therefore, there is an important educational challenge within the design of a participatory software: in that the participants should be guided to understand design and the consequences of their design decisions.

This paper will describe both the exploratory research involved in the development of a participatory design application and the evaluation of the software on the basis of the user trails with participants. The paper will also describe the methodology used to compare the participants’ designs with professional designs for buildings of the same type. The paper will conclude by presenting a new curriculum for architectural education based on the principles of user-centred design in which the architect’s focus shifts from the expression of their own ideas to being the facilitator of the participants’ ideas.

INTRODUCTION

In 1971 the Design Research Society, under the leadership of Nigel Cross, organised a conference called Design Participation which brought together leading policy experts, design theorists and software developers (Cross, 1972).

At this conference the idea of using the emerging technologies of computer-aided design (CAD) for design participation was discussed and further pursued by Nigel Cross and Tom Maver in an article published in the Architects’ Journal (Cross and Maver, 1973). This idea was further supported by John Lansdown, who was the chair of the civil engineering subcommittee of the UK Science Research Council. As a result of these discussions a research project into Computer Aids for Design Participation was started at the ABACUS research unit at the University of Strathclyde in 1975. The objectives of this research were three-fold: first, to develop a suitable CAD system for use by lay participants; second, to test the usability of this system with participants and third, to objectively evaluate the quality of the designs produced by the participants in comparison to the design of professional architects for equivalent buildings.

This project represented a unique empirical study in the field of Design Research. However, we should remember that this work used what by today’s standards would be considered as incredibly primitive interactive computing systems and before computing became a ubiquitous ‘user experience’. For the participants this was most probably their first experience of computing, let alone interactive computing.

HISTORICAL CONTEXT

The 1971 Design Research Society’s conference on Design Participation reflected a growing interest during the preceding decade in a number of key precursors to design participation. Within this period, the year 1964 emerges as a pivotal moment with the publication of four seminal texts.

First, the publication of Architecture without Architects by Bernard Rudofsky (Rudofsky, 1964), which explored the history of vernacular architecture. Rudofsky suggested that convenient, adaptable and in many cases highly aesthetic buildings and urban forms could emerge from an untutored vernacular design process.

Second, in the 1960s, there were a number of significant architectural practitioners and theoreticians who articulated what they considered to be the practical, social and political imperatives for community architecture. This included John Turner, working in Peru between 1957-1965 (Turner, 1972). The advocates of community architecture recognised that
architecture intersects with social policy and therefore inevitably with ideology. However, they rejected conventional highly interventionist urban (re)development and associated community disruption. Instead community architects emphasised local activism, focussing on incremental improvement, building on existing community organisations and vernacular architectural traditions via self-help initiatives. These ideas were often characterised as being counter culture, non-conformist and represented a dimension of idealism and social action which was completely orthogonal to the prevailing architectural and political ideologies.

Third, in Notes on the Synthesis of Form, Christopher Alexander (Alexander, 1964) made the distinction between ‘unselfconscious’ and ‘self-conscious’ designing. We don’t know if Alexander, Rudofsky and Turner were aware of each other’s work. It certainly appears that Alexander supported the contention of Rudofsky who associated unselfconscious design with societies that design and build their own buildings, which are often transient or are frequently re-built. Alexander suggested that because the builder is the building user, the resulting architecture is ‘unselfconsciously’ adapted and ‘fits’ the needs of the user. On the other hand, he associated self-conscious design with the establishment of a distinct specialist profession of architects, who develop their own system of ideas, discourse and criticism. For Alexander, architecture became the self-conscious expression of the architect. He suggested that these academic and professional preoccupation are overlaid on and potentially mask the needs of the building users.

Fourth, in Plug-in City Peter Cook and the Archigram group (Cook, 1964) explored the idea of a technological urban service and support structure for flexible housing units which could be reconfigured to adapt to the changing, even transient needs of the occupants. The implication was that the occupants would be able to design, customise and reconfigure their individual units, within the defined constraints of the technological support system so that the overall architectural effect would be the aggregation of the occupants’ designs. While Plug-in City represents a delightfully playful combination of science fiction, architectural fantasy and cartoon-like illustration, it effectively questioned how new construction technologies combined with new architectural thinking might transform the social, technical and professional status quo.

Fifth, in 1972 John Habraken published Supports: an Alternative to Mass Housing (Habraken, 1972) in which he advocated building public housing structures with continuous internal spans so that the internal spatial arrangement of the housing units could be customised to suit the needs of the individual occupants and potentially could be reconfigured for subsequent occupants. In the UK, architects at the Greater London Council (GLC) used the ideas of Habraken in the PSSHAK project (Rabeneck, 1975). PSSHAK stood for ‘Primary Support Structures and Housing Assembly Kits’. This was used by the GLC in the design of public housing at Stamford Hill, Hackney and at Adelaide Road, Camden.

PSSHAK “was a system of prefabrication devised by Nick Wilkinson and Nabeel Hamdi, based on the writings of the Dutch architect Nicholas Habraken and designed for mass housing”. PSSHAK “also aimed to demonstrate the feasibility and benefits of participatory design methods in the public sector, the designer acting as a ‘skilled enabler’ instead of the ‘expert architect’, approaches that Hamdi and Wilkinson have pursued ever since.” (Rabeneck, 1975)

Sixth, during the 1970s and 80s the ‘self-build’ movement developed in the UK, in part by leading architectural pioneers such as Walter Segal. As Colin Ward has suggested, Walter
Segal’s ideas challenged.....

“the assumption of both regulatory authorities and providers of finance, that a house should be a fully-finished product right from the start, rather than a simple basic structure that grows over time as needs grow and as labour and income can be spared. Segal’s achievement was to devise a way of simplifying the process of building so that it could be undertaken by anyone, cheaply and quickly. He insisted that his was an approach, not a system, and he made no claims for originality or patents.” (Ward)

The historical context and pre-cursor research all contribute to the arguments for Design Participation. The key issue is ‘user satisfaction’ or conversely the issue of ‘user dissatisfaction’. We can further decompose this as:

• For most people, the building is not an end in itself, but is an intermediate object which indirectly may be satisfying because it enables activities which are the primary focus.

• The lack of user control over the immediate built environment creates a sense of powerlessness (hence user dissatisfaction).

In summary, it is generally recognised that the value of design participation comes from the process of participation (the sense of involvement and control) and from intangible aspects of the building rather than from measurable attributes of the physical building (Broome, 2005, quoting Turner, 1991 and Ward, 1985).

DESIGN CRITERIA FOR A SOFTWARE SYSTEM FOR DESIGN PARTICIPATION

The primary objective of the ‘Computer aids for Design Participation’ project was to create a computer system to support practical participation. Rather than focusing exclusively on these practical considerations, it was decided to implement this objective within the broader goal of creating a computer-based research tool which could be used to explore how participants design. What was being researched was more than a participant simply drawing or modelling of a building. It was a process of decision making and trade-offs in a highly complex multi-variate solution space. This combined both visual building geometry and other representations of requirements and building performance. Therefore a key element in the participatory design system was how to present information that could support decision making and trade-offs.

A key feature of the Habraken/Supports research and the Segal/self-build projects, was that they both offered the participants the opportunity to explore what might be called ‘design freedom’ but these systems also communicated the limits or constraints to that freedom. Therefore, it was concluded that it was also essential that a computer based participatory design tool should present similar design freedoms and also communicated the limits to this freedom so that the participants would be able to express their ideas, but not in an unrealistic way. There was a general feeling that the participants were vulnerable to having their designs dismissed (by professional architects) for lacking feasibility. Therefore the researchers felt that there was a need for the design system to support the participants in developing realistic and feasible designs.

The design of the participatory tools brought together existing research interests in performance-based architectural computing and human computer interaction, namely:
From the architectural computing perspective:

- The advantage of a computer graphic representation of a building is that it provides facilities for the user to create drawings and models which require less manual drafting skills and can be easily edited to create pristine alternative designs. This enables designers [both professional and lay participants] to experiment with different layout configurations and to explore trade-offs and the consequences of different design decisions. There are many additional benefits by representing a design in a computational form as it provides a direct link to performance analysis software.

- In the design of functional buildings such as hospitals and schools there may be complex space allocation rules or circulation requirements. Certainly for professional architects [and also by implication for lay participants] there is a need for ‘decision support’ tools to help the designers make these trade-offs and decisions. Often this involves dynamically re-computing space related measures as the consequences of design decisions.

- As a by-product of the computer graphics system used, both existing professional designs and the participants’ designs could be represented with the same stylised graphics. This removed visual cues from the professional designs which might otherwise have indicated their professional origin and authorship. This allowed the professional designs and the participants’ designs to be compared completely ‘blind’.

From the human computer interaction perspective:

- A computer graphics representation of architecture is an important ‘transitional’ representation between ‘man and machine’. It is ‘human-readable’ in that it can be viewed and edited as graphics by the designer [professional or lay participant] and it is ‘machine-readable’ in that it can be interrogated by other analysis and simulation software.

- A computer based interaction system can provide an adaptive learning environment, where the participants can develop their skills completely at their own pace, not forced as might be the case with a conventional tutor-student learning situation.

- Simple design rules can be encoded into the system in the form of a computerised expert tutor. The participants can be given optional advice about the viability of their design without any inter-personal pressure, which might be the case with the presence of professional expert.

- The participants’ design activity can be instrumented for subsequent playback and analysis. This enables the participants’ complete design process and all the intermediate steps in this process to be reviewed by the research team.

THE PARTIAL DESIGN RESEARCH APPLICATION

The resulting development of the ‘PARTIAL’ design research application represented the convergence of on-going research at ABACUS into the development and deployment of professionally-oriented CAD and architectural decision support systems and contemporary research in human-computer interaction to create task-oriented adaptive learning environments (Aish, 1977).

PARTIAL stood for PARTicipation In Architectural Layout. PARTIAL assumed that there would be two different kinds of user: first, a researcher [or participatory architect] would define the participatory design task and who would review and interpret the results of
the participants’ design and second, a number of participants who would create the designs. To support this research workflow, PARTIAL was in fact developed as a suite of three programs.

PARTIAL 1: this program was used by the researcher to define the design problem, including the space budget (or architectural program) and any fixed building geometry, for example if the design task was a conversion or extension to an existing building. The researcher could also select the different performance measures that would be displayed to the participants, including the visual characteristics of the performance display, its datum and scale. In addition, the researcher could select which tutorial and advice options would be available to the participants.

PARTIAL 2: this program was used by the participants within the context established by the researcher using PARTIAL 1. The design activity of the participants, how the architectural layout was developed and revised was recorded in a transaction or history file.

PARTIAL 3: this program was used by the researcher to analyse the transaction file, including the ability to display the state of the participant’s design at any moment in the design history.

CHOICE OF BUILDING TYPE AND PARTICIPANT

One of the critical decisions in this research project was the choice of building for the participants to design and therefore the choice of participants. Many previous examples of design participation had focussed on housing. In this project we wanted to move away from domestic buildings and the associated issues of subjectivity and apply design participation to a functional building where there was a professional relationship between the participant and the building owner or institution. At the time of this research and in the immediate context (the city of Glasgow) there was an ongoing local government program to build nursery schools. It was decided to use nursery schools as the building type and nursery school teachers as the design participants. The ensuing participatory design sessions harnessed the very immediate and practical concerns of the teachers about the design of new schools which they might have to teach in. Also the researchers had access to a set of architect-designed schools to act as a reference for the participants’ designs.

In practical terms, the design of nursery school had to fulfil complex space allocation rules or ‘space budget’. Within the ‘space budget’ there were a defined number of rooms of different types. Both individual rooms of a particular type and the total area of all rooms of a particular type had to be within a defined minimum and maximum area. It was anticipated that as the participant was designing the school, it would be important to continuously re-compute the remaining space ‘budget’ yet to be allocated. This was not a task that the participant could be expected to complete using paper and pencil calculations. The participant’s space allocation task could be more effectively support by a computer-based recalculation method operating continuously in the background.

The average of the performance measure of the set of professionally design nursery schools was also used as the ‘datum’ for the performance display of the participants’ design (figure 4).

THE DESIGN PROCESS

The initial training was in the form of a tutorial where the researcher explained to the participants the key aspects of the program including drawing, the decision support tools,
Figure 1 The participant's initial design sketch

Figure 3 Checking the space allocation

Figure 5 Space allocation during the design process

Figure 7 The participant's design at time A

Figure 2 Advising on possible layout issues

Figure 4 Displaying comparative performance

Figure 6 Changes in layout performance

Figure 8 The participant's design at time B
and the evaluative tools. Typically the research would explain, “this is how you draw a room” (figure 1), “this is how you check that rooms you have drawn forms an appropriate room layout” (figure 2), “this is how you check that your design is within the space requirement” (figure 3), “this is how you compare the performance of your designed with other existing nursery school designs” (figure 4).

One participant interrupted this explanation, turned to the researcher and said, “You can go away now. I am going to design my nursery school”.

Using PARTIAL 3, the researcher was able to replay the history of the participant’s design process. Figures 5 and 6 show different aspects of the design history as the participant’s layout of the school evolved. The initial part of the design process appears to involve the build-up of room areas while the subsequent part of the process appears to be focussed on changing the design to improve layout performance. The researcher could select different points on the time (x) axis in the design history graphs and recover the participant’s design at these time points. For example in figure 5, the researcher has selected times A and B and the corresponding participant’s designs are displayed in figures 7 and 8.

CASE STUDIES

A number of case studies were carried out using PARTIAL with Nursery School teachers as the design participants (Aish, 1979), (Watts and Smith, 1979) and (Smith and Watts, 1979), including:

- Asking participants to rank existing professionally designed nursery schools
- Asking the participants to design their own nursery schools including some very detailed recordings of the design protocol used (figure 9). These studies demonstrated the number of different design requirements and issues that the participant was concerned with and was able to manipulate and combine into a single coherent design solution.
- A second ranking exercises where the participants were asked to rank all the participants’ design including their own. It was not surprising that each participant ranked their own design first.
- A group design sessions where a number of participants combined their individual designs into a common solution.
- A third ranking exercise after the group design session. In this third ranking task, the group design was also included in the set to be ranked together with all the individual designs.

Interestingly on the re-test, it was the group design which was consistently ranked first. “In fact in most cases, the individual considers the eventual group design to be more acceptable than their own original. This would suggest that cooperative involvement produces a more satisfactory outcome to the participant”. (Watts and Smith 1979) Watts and Smith addressed the question of how to objectively evaluate the participants’ design. They selected six designs developed during the previous participation sessions and six professional designs. The professional designs were redrawn using PARTIAL so that all the designs were presented in the same stylised graphics used for the participants’ designs. The two groups of designs were randomly merged into a common set, thus creating a completely ‘blind’ ranking task. The use of the same stylised graphics meant that there were no visual cues which could be used to distinguish the professionals’ and participants’ designs.
A group of professional architects, not involved with the design projects, were asked to rank these designs in order of preference and similarly a group of nursery school teachers, not involved in the participatory design project, were also asked to rank the designs. The ‘non-involved’ architects equally ranked the architect-designed schools and the participant-designed schools. Effectively this meant that a group of independent professional architects could not distinguish the architect designed schools from participant designed schools. The ‘non-involved’ nursery school teachers consistently ranked the participant-designed schools above the architect-designed schools.

“It would appear that the participants were able to produce layout designs which were as acceptable to [‘non-involved’] architects as those produced by architects using a comparable brief, and more acceptable to fellow [‘non-involved’] school teachers than those produced by architects” (Watts and Smith, 1979).

CONCLUSIONS FROM THE PARTIAL RESEARCH

The PARTIAL project at ABACUS combined some highly original developments in end-user interactive computing with the formal testing of the effectiveness of these tools in architectural design. One of the key aspects of the PARTIAL system was the ‘instrumentation’ of the participants’ design process. There are many further aspects of design participation that could have been explored with this system but time and resources did not allow. For example, the potential exists to analyse the participants design strategies, how different aspects of the design layout were developed or abandoned. Then there were the group design sessions, where it would have been fascinating to monitor the negotiations between the participants and to track how different aspects of the various participants’ design were selected, combined or transformed into the group design.

OTHER RELATED RESEARCH

There are other related research areas, although a more detailed description and discussion is outside the scope of this paper.
RESEARCH INTO 3D TANGIBLE USER INTERFACE FOR DESIGN PARTICIPATION

During the participation research there were concerns that computer graphics may not be an ideal interface for lay designers and that a 3D Tangible User Interface (TUI) might offer a more direct way for the participants to create and review their work. A TUI could be a form of Lego which the participants directly modelled. A TUI is also ‘machine readable’, thereby providing input into a computational design system. In the late 1970s and early 1980s the development of 3D TUIs was pursued independently by a number of researchers. This research and its application to the Segal self-build system was reviewed in the ‘Architects’ Journal’ (Evans, 1985). It was concluded that this type of interface may offer some advantages up to a certain level of complexity, after which its utility diminishes. The coarse ‘granularity’ and other positional and angular limitations essentially interfere with the architectural expression and fidelity of the user’s design and significantly restricts expected ‘design freedoms’. While it may be easy to initially construct a model with this type of ‘block modelling’, reconfiguring the physical model soon becomes significantly more arduous. The advantage of tangibility is outweighed by the loss of fidelity. Similar criticisms have been applied to other architectural applications of Lego, for example by Changizi (2012).

MASS CUSTOMISATION

Commercially available mass-customisation is usually restricted to the customer’s choice of colour and finishes and does not allow for any change in configuration. This type of mass customisation does not appear to be relevant since it fails to address the issue of the participants’ control over ‘configuration’ which is generally recognised to be the key ‘design freedom’ in participatory architecture. There are examples of mass customisation of furniture using consumer-driven parametric variation of a standard prototype. It is difficult to see how this would scale to architecture. Different approaches to mass customisation at both the product and the architectural scales are discussed by Kolarevic (2015).

DESIGN PARTICIPATION BY SELECTING FROM PRE-COMPUTED OPTIMAL DESIGNS

Doe and Aitchison (2015) researched consumer choice in housing where the client can select from a set of precomputed pareto optimal house designs. All designs are equally energy-efficient but have different configurations and achieve their efficiency in different ways. While this is an interesting experiment, the participants are not in control of the configuration. For example, we might hypothesise that a participant might prefer their own configuration even if it might be marginally less efficient than the set of precomputed designs on offer. However, this research did not support this approach.

Therefore there is little opportunity for the participant to explore ‘design freedom’ or for the participant to learn about trade-offs between configuration and building performance.

GAMIFICATION OF DESIGN

‘Block’hood’ is a design game developed by Sanchez (2015). It is recognised that games can sometimes provide a better understanding of certain systems and processes than other more conventional forms of presentations or explanations. However, games often present a limited, risk-free, sanitised view of reality. While games have the potential to provide training for some real world activities, the challenge is how to help the ‘gamer’ make the transitions to ‘real-life’; specifically does the ‘gamified design environment’ present realistic design freedoms and constraints. Could a design created in such an environment actually be constructed? ‘Gaming’ may be satisfying. The concern is that it can become an end in itself and a substitute for reality.
EDUCATIONAL IMPLICATIONS

Participation is not just a question of a professional architect ‘consulting’ the future building users, selecting which of the participants’ ideas to include and then assuming responsibility for the design. Participation means that the potential building users are the creative drivers of the design process, with... "the designer acting as ‘skilled enabler’ instead of the ‘expert architect”, as Hamdi and Wilkinson suggested (Rabeneck, 1975).

So what is the role of a participatory architect? Let us compare this role to that of an architectural educator. An architectural educator is usually an accomplished practitioner in their own right who additionally uses their creative skills to help their students to develop their own creativity.

Similarly a participatory architect should also be an accomplished architect in their own right who uses their creative skills to help participants to design buildings which are their expression.

Participation requires some re-focussing both educationally and professionally. The architect role changes from being the designer of the individual building to a broader more strategic role, that of being the ‘systems architect’ of the whole participatory process. Indeed, there are some really interesting ‘system design’ challenges for the architect. For example, one challenge might be creating a robot-assisted self-build system, using reconfigurable components, which could be potentially used for retrofitting existing buildings. Another software and usability challenge might be to create the next generation of computational participatory design tools, potentially using ‘augmented reality’ and simulation-based design. This ‘systems design’ role is no less creative than conventional architecture, but designing the tools and processes that encourage other peoples’ creativity may require additional technical insights and skills.

CONSUMER SYSTEMS ARCHITECTURE

There are new opportunities: Architecture has the potential to be a critical part of a ‘consumer electronics - digital media – built environment’ spectrum of customisable ‘user experience’. Design participation has the potential to be applied to all levels of this spectrum.

To this end it is proposed that the ideas pioneered in past ‘Design Participation’ research and community architecture should be consolidated and updated into a new course on ‘Consumer Systems Architecture’. This course would address the question: what are the concepts, methods and skills that a participatory architect will need to be equipped with to serve and to prosper in the 21st century?

It should be stressed from the outset that the proposed course would be completely complementary to existing architectural education. It would build on established traditions of developing the students’ ability for original and critical design thinking. Building on this foundation, the course would be extended in two complementary directions: first, it would have a strong social dimension, implied by ‘user centric’ and ‘community centric’ design and second, it would have a strong technical dimension, focussing on a broader range of electronics systems and computational and interactive technologies.

The title “Consumer Systems Architecture” combines:
- Consumer: because the course is completely consumer and community oriented
• Systems: because the course focuses the student on the ‘systems design’ issues involved in the participatory design of different types of buildings rather than on the student’s own design of a particular building.

• Architecture: because the course unifies the concepts and practice of ‘systems architecture’ with ‘building architecture’.

Building on existing architectural education (with its focus on context, form, function and making) this curriculum and the related design projects might include:

• Computer Science: Computation underpins all aspects of algorithmic design, embedded and real-time systems and human computer interaction. The emphasis of this module is to help the student progress from ‘exploratory’ programming to a more sustainable form of software engineering based on computer science concepts and software design methods. Just as with drawings, models and essays, architectural principles of structure and legibility should be applied to all aspects of the students’ work including programming. Related design project: Write a program for someone else (not the student) to use and then evaluate its usability.

• Human Computer interaction: Principles of HCI and User experience (UX) design: The emphasis of this module is to help the student understand the different capacities of humans and machines and how these can be combined to create an effective man and machine system. Related design project: using software tools (such as ‘Processing’) to create a simulated user interface, for example to control an environment and validate the interface design by testing it with a panel of lay consumers.

• Systems Integration: Study the role of different engineering systems in buildings and how these can be integrated, including the role of multi-functional components that perform key roles in unifying different building subsystems. Related design project: design a multi-functional component and demonstrate its role within a building configuration.

• Design Optimisation: Understand how to create and navigate a design ‘solution space’ and how to create a fitness function. Related design project: use design computation tools to build and explore a solution space. Test the use of the design space solution explorer with professional architects and lay building users.

• Consumer research: Understand consumer demographics and how to find or create a market niche. Related design project: research the market for a new architectural user experience, architectural product, or service, including holding ‘focus groups’ to gather ideas and validate design assumptions.

• Community and consumer engagement: Understand different models of social engagement in design, including: mass customisation, design participation, team decision-making, direct democracy. Related design project: select a building type and a group of participants and conduct a ‘design participation’ project, including the selection of design rules and performance measures to be used. Compare the participants’ designs with professionally designed buildings of the same type.

• Research Methods: Architecture integrates ideas across the whole spectrum of the sciences, social sciences, humanities and the arts. This integration often blurs the distinction between the essential and the expressive, between performance and persuasion. A student architect needs to be a passionate creator but also a dispassionate and rigorous evaluator of architecture, particularly of their own work. An architectural education should help the student prepare for the integrator and the evaluator roles. It should help the student to understand the different types of theories and research methods in the sciences, social sciences, humanities and the arts and given them the opportunity to practically apply the different research methodologies.
A ‘Consumer Systems Architecture’ course would be an example of research-based architectural education which harnesses the students’ design creativity, but also gives the students practical experience of using empirical research methodologies to validated design ideas by consumers. In this way we can educate a new generation of architects who are technically and creatively equipped to drive the ‘democratisation of technology’ and thus the ‘democratisation of architecture’.

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REFERENCES

Doe, R., and Aitchison, M., 2015, Multi-criteria optimisation in the design of modular homes, CAADe 2015
Kolarevic, B., 2015, From Mass Customisation to Design ‘Democratisation’, Architectural Design 85(6), Wiley

[Note: The ABACUS occasional papers referenced here are currently being digitised and are expected to be available on CUMINCAD http://cumincad.scix.net/cgi-bin/works/Home in the near future]
Digital tools beyond aesthetics: mass creativity and the enablement of emergence

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INTRODUCTION

Digital design tools are now undergoing a transition of application scope, expanding beyond their initial technical domains and leveraging the flexibility of the digital medium - in which they exist - to its fullest extent.

Digital means of communication are enabling the self-organisation of new cultures as well as decision-making structures revolving around the possibilities inherent to the digital realm. Design tools are slowly catching up - to a certain extent - by building upon the flexibility of parametric design in order to improve the communication channels of the design process, thus signalling the achievement of a certain “digital maturity” of the architectural design community. Unfortunately, the current state of collaborative design software is catering exclusively to the needs of the technical stakeholders involved in the design and building process, namely architects, engineers and builders. In our contemporary world, where social change and action is not only supported but triggered by digital communication tools, the design disciplines stand to lose credibility if they will not take initiative and tap into the existing expectations of collaboration that today’s society now harbours.

The following paper puts forward a new research direction for the design of digital tools that aims to investigate ways in which to make the design process more open and approachable by non-technical stakeholders. A design never exists independently from the tools that are used in its creation and vice versa. As such, it is important to note that this entails both a technological development effort as well as the elaboration of a methodological package that supports the meaningful usage of said tools - essentially an active tectonic study that manifests as an accelerated feedback loop between both tool and process development.

STRUCTURE

In the first section we put forward the concept of mass creativity as an extension of mass collaboration. Within this context we introspectively define the role of an architect as a translator between the various interests of the stakeholders involved in the design process. The second section subsequently looks at the tools that a designer has at hand to accomplish this role. We critically analyse the notational paradigm upon which contemporary digital tools are based on and outline both their disadvantages and strengths that can be speculated. Following this, the third section concerns itself with outlining a case study which reveals how a different approach to using digital
design tools – one that renounces the classical notational paradigms – can be applied. Two more similar examples are outlined in the fourth section in support of “de-aesthetised” digital design. We subsequently conclude by acknowledging the importance of creating digital tools and methodologies that support the designer in fostering the emergence of mass creativity, thus responding to one of the main challenges of today.

**A CASE FOR MASS CREATIVITY**

Collaboration has become embedded within today’s design environment as projects are no longer the result of an isolated creation process, but an emergence of a myriad of interactions between various human and non-human actors. Architects, engineers, banks, communities, politicians and various other animate and quasi-inanimate agents contribute towards the final embodiment of a specific design and its subsequent evolution.

As such, we can justly state that the built environment is, at a global level, an emergent feature that results from countless interactions of material and social flows. Extrapolating further, there is no fundamental difference to speak of between the laws that govern the processes that give birth to cultural artefacts, and those of natural artefacts: they both share the same generative principles loosely aggregated under the umbrella term of “emergence”.

The contemporary new materialist school of thought, spearheaded by science and technology studies and anthropology, have gone further and argued for the dissolution of the Modern dichotomy between Nature and Culture (Latour, 1993), (Descola, 2013). Furthermore, the concept of a static, finite, encapsulated object is no longer valid. In its place we now observe the emergence of large-scale patterns from the interactions of various flows of matter-energy. Bruno Latour calls them quasi-objects: objects that are only defined by their web of interactions - a conglomeration of threads representing process flows that give birth to recognisable features (DeLanda, 2000). These ideas lend themselves well to aspects of computational design that we shall elaborate on in the following section.

One of the most powerful implications of this “non-modern” context is that we, as designers, are part of the swarm of decision makers whose actions lead to the crystallisation of the built environment. Our creativity and contribution to the development of a project is equally valuable as that of all the other stakeholders involved in the process, both animate and inanimate.

What seems initially to be a harmless statement of the status quo becomes a game changer if properly embedded into the rationale of design methodologies: it entails a redefinition of the architect’s scope of action and role. To a certain extent this has always been the case - nevertheless by centring the above statement as the core of the designer’s position we do raise the need to adapt both the methodologies that we apply when designing as well as the tools we are using to communicate and enact that respective design. The role of the architect as “master builder” is no longer feasible due to its scope which, within the contemporary practice, expands to unsustainable dimensions.

Nevertheless, one can argue that the designer - within the group of stakeholders associated with a project - has a polarising position because he needs to process information flows coming from a wide array of sources: architectural, economical, social, etc. This does not translate to a position of control, as “classical” architectural education would teach us - it is a position of greater responsibility. If we define a design project as an emergent feature from the interactions of various agents, then the architect’s main role is thus revealed as
being the facilitator of meaningful interactions between all the relevant stakeholders.

Consequently, the designer is a conduit of communication, constantly translating between the languages of expression of the various stakeholders involved in the project, including his own. Among the many languages spoken we find, for example, financial analysts talking in future values and internal rate of returns, engineers articulating finite element analyses that evaluate a design for its structural consistency, local communities voicing their ideas in social terms that do not lend themselves easily to quantification, and so on.

Essentially, an important point to acknowledge is that all stakeholders are creative. For example, the financial design that enables the project to be built embodies the same qualities as the innovative concept that the designer brought to the table. The expression of this creativity takes various forms and is not universally translatable across different groups without active effort. Ideally, the design process is not one of just mass collaboration, but one of mass creativity that results from a harmonious negotiation process.

DESIGN TOOLS & ARCHITECTURAL NOTATION

The means of communication and tools an architect has access to need to enable the expression of creativity from all involved stakeholders. In such a diverse environment, as usually is coagulated around contemporary design projects, the lack of good communication channels and/or the inability to translate between disciplines and interest groups usually leads to friction, dissatisfaction and compromised results.

Classical architectural notation, developed by Alberti in the 15th century, has focused on developing identical copies between the design of the building (virtual) and its embodiment in reality (construction) (Carpo, 2011). Plans, sections, elevations, and so on, are essentially schematic notations that encode architectural information into a language that is controlled by a certain set of standards. As such, one can design, communicate and build within a single system.

Digital design tools have evolved as analogues of the same paradigm as classical architectural notation, their main goal being that of making identical copies of the information that they encode. For example, Ivan Sutherland’s Sketchpad program, considered the precursor to all CAD software, was essentially a digital drafting tool: it replaces the draftsman’s traditional pen with a “light-pen” and paper with “digital” paper. As such, we can argue that the notational mechanisms of today are identical to that of classical architectural script, which has remained unchanged since the Renaissance. To this day, all architectural drafting software is essentially a direct transposition of Albertian notational principles into the digital medium.

Another notable evolutionary step in the design of digital tools is that of the increased linkage with fabrication techniques and construction site management. By weaving together building and material constraints, digital tools have greatly expanded the geometrical vocabulary that is now accessible to the designer. This movement, which began in the early 1990s, has been appraised as “The Digital Revolution”. In its first stage it negated the principles of mass production and standardisation by introducing a new formal agenda based upon the new found expression liberties offered by the “isolated” digital medium (Carpo, 2013).

This leads us to the second stage of the digital revolution in architectural design; going beyond mass customisation, by speculating the qualities of the “connected” digital
medium. In this way, we would argue for the transition to mass collaboration and, subsequently, to mass creativity, thus empowering the contemporary design process—one in which every stakeholder is creative and is able to define value.

In the past, exploration of variation was limited due to the friction of the analogue medium (pen and paper) in which architecture was expressing itself. The virtual realm has effectively eliminated this barrier and thus paved the way for a comprehensive exploration of the “objectile” (or quasi-object) (Latour, 1993). Software like Grasshopper or Dynamo enable the architect to no longer be author objects, but processes whose result is not a single finite object, but, as mentioned above, quasi-objects, or families of objects. Various performance measures—feasibility, material constraints, etc.—usually act as selection criteria which collapse the objectile into a single object that is subsequently built.

Here we have to make a technical distinction between the “isolated” digital and the “connected” digital. Current digital design tools rely mostly on the qualities of the “isolated” digital medium, i.e. embodied in a single technological unit: the designer’s computer. Collaboration is achieved by packaging finite designs and exchanging them via emails or other surrogate management systems. The connected digital medium—i.e., the internet—offers a wildly different set of qualities that are yet to be integrated and repurposed for the use within design process.

Generalising, the current Albertian notational paradigm does not address the need for a flexible and interchangeable language that would allow the designer to enact his negotiator role. While being extremely efficient for aesthetic and technical exploration, digital tools still structure communication in a non-agile way that is focused on describing the “final” object. The vocabulary it uses is not always flexible enough in order to be articulated in an accessible way for all stakeholders, both technical and non-technical.

CASE STUDY: PROBLEM & CONTEXT

When we are faced with a set of tools for a linear process, for instance, packaging a finished design to email to a client, the space for unexpected encounters (emergent possibilities) is narrowed, forcing a design environment that lacks in dialog. Non-technical stakeholders (communities, financial analysts, government authorities, etc.) are not yet integrated in the (digital) design chain—on the contrary, current practice usually positions them in an adversarial role and does not allow them to exceed their pre-assigned conflictual position due to the limitations of existing design tools and methodologies.

This problem manifested itself during the development of a feasibility study for a future large-scale urban development in the heart of Brussels, the “traditional” design approach failed and a new, flexible design process had to be developed and communicated in order to meaningfully respond to the questions posed by the assignment. This study was undertaken by the author while employed at Bogdan & Van Broeck, an architectural consultancy and design office based in Brussels. Specifically, the assignment called for an exploration of the possible directions in which a large site owned by the Flemish Government could evolve within the context of a PPP (public-private partnership) development. Initially the brief required an investigation into the functions that would meaningfully fit on the given site coupled with volumetric explorations on various organisational principles that would accommodate the given proposed functional programmes.

The main stakeholder groups involved in the project consisted of The Flemish Government (VO), The Developers and Private Investors and, finally, The Policy Makers. Bogdan &
Van Broeck, as the office in charge of elaborating the study, was situated as a mediator between all three parties. When the initial outline of the study was being formulated, the traditional approach was failing due to the fact that the representational means were not adapted to the interests of the stakeholders that had vested interests in the project. “Classical” architectural notation and drawings, while being seductive and incorporating a great amount of information in an efficiently small package, were not embodying the right message and were forcing a specific approach that was destabilising the design process.

With hindsight, we can say that the main problem was the language used to communicate and synthesize the decisions being taken. Urban and architectural plans, coupled with textual descriptions, were not versatile enough to translate between the interests of all the involved parties. For example, variations of the masterplan were proposed in a traditional form, with schematic drawings. These were coupled with textual descriptions that presented social implications and financial outlooks that emerged from the design process. While initially an unassuming presentation mode, this was triggering The Flemish Government’s representatives to request more detailed and eye-catching designs, while the policy makers were increasingly sceptical due to the apparent lack of “substance” that the increasingly realistic presentation drawings were making. At the same time, the developers were becoming convinced of the fact that the proposals were not actually financially feasible due either to their too “glossy” nature or due to their too high “socially-aware” functions. This led to the development of mistrust between the involved parties, subsequently halting the design process.

While the proposed solutions were, essentially, the embodiment of the negotiations between all stakeholders involved, they were not revealing the inner mechanics of the synthesizing process that we were undertaking. The negotiation process required to develop the proposed scenarios was not visible – even if value was defined taking into account the priorities of all stakeholders, it was not collaboratively defined. As such, consensus was
impossible to reach: the three parties involved did not understand each other’s priorities and what impact they have on the other’s set of parameters.

To sum up, the stakeholders did not speak the same language. Classical architectural notation, based on the representational paradigm, was not enough to enable communication between the project’s actors – on the contrary, we can argue that, because it was forcing the designers to present “finite” objects/geometry, it was detrimental to the design process.

CASE STUDY: RESOLUTION

We realised that the value of the feasibility study we were elaborating lay not in the actual finite designs that we were delivering, but in the processes of communication and translation that we were undertaking. As such, we decided to package the negotiation process itself into a deliverable tool by creating a simulacrum of a “dj mixer” that will allow intuitive control of relevant parameters, provide users with direct feedback regarding choices and be relevant to all stakeholder groups, regardless of their background. This was achieved by developing, together with a financial consultancy firm, a parametric model that took into account architectural, urban and, most importantly, financial parameters (figure 1). Subsequently, this model was transformed into an interactive negotiation application that was made accessible to the extended group of stakeholders as a base for negotiation (figure 2).

During the development and (brief) testing of the application, several important aspects were revealed as being critical. First, the categorisation and selection of parameters played a crucial role in alleviating the “paradox of choice”: when confronted with a wealth of modifiable inputs, the users were unable to reach a satisfactory solution. As such, reducing the parameters to the minimum – without sacrificing any critical ones – was instrumental to reach the increased accessibility levels desired. Second, the inner logic of the model was hidden from the end-users. Parametric models can be daunting to the non-expert, and, subsequently, discourage them from their usage. This resulted, in isolated cases, in a diminishing of trust in the calculations being performed. Nevertheless, this negative aspect was outweighed by the fact that previously non-technical stakeholders, previously shy but expressing a strong passive discontent, were now willing to approach and join the
conversation due to their new-found empowerment. Their inclusion was instrumental to unblocking the design process.

Third, and most importantly, we emphasized the flow of information by graphically displaying the links between all relevant parameters and their implications (figure 4). This allowed the stakeholders to understand and grasp the implications of their preferences with regard to the others’ definitions of value (and profit). A global understanding of the system resulted: all actors involved in the design process were finally aware of each others’ priorities and ways of thinking. It was through this distributed global understanding of quality and value that the proceedings were unblocked. Essentially, the study’s main value revealed itself in the creation of the aforementioned sense of understanding between the stakeholders.

BEYOND AESTHETICS

Up to now, the flexibility of the digital medium has been leveraged purely for the aesthetic exploration and technical optimisation of designs which, ultimately, are collapsed into one “single” or “final” solution. Nevertheless, we strongly believe that, to a certain extent, digital tools can now go beyond aesthetics. How can digital tools go beyond aesthetics and help the designer in his role as a conduit of communication? We have presented above one example of how a parametric model can act as a translation tool between the various languages employed by a specific set of stakeholders, both technical and non-technical.

Another recent example can be found in the work of Dominik Holzer and Steven Downing, DesignLink (Holzer, 2010). The authors propose “optioneering” as a design methodology that encourages “a form of discourse where design partners negotiate the criteria space for a design problem at the outset of their collaboration” (Holzer, 2010). Coupled with DesignLink, a software specifically developed to enable this kind of high-frequency collaboration, albeit amongst technical stakeholders only.

An outstanding example of using digital tools as a communication instrument that leverages collaborative design principles can be found in the work of R. Aish and J. Fleming from 1977 (Robert Aish, 1977). The authors devised a parametric computer aided design system (PARTIAL) geared towards defining a context in which both professional designers (architects) and end-users can collaboratively design and evaluate a particular building type. The authors’ intention was to “provide a context where the designers/
participants could combine their own subjective design ideas with the necessary technical requirements” (Robert Aish, 1977). The research presented by the authors is from a time when the “connected” digital medium (the internet) didn’t exist yet in a form that was accessible to all, or, for that matter, had a name. Nevertheless, it shows great foresight by aiming to enable all participants to “operate directly on […] a complex, multivariate, but nevertheless, extremely real decision making process” through the use of digital design tools.

Enabling participation and, through which allowing for the emergence of mass creativity, should be a key driver in the development of future design tools. Non-technical stakeholders must be included in order for one to be able to properly define value in a collaborative manner. “Quality” can mean one thing for the developer and a completely different thing for the designer, and hold yet another meaning for the surrounding community. As such, digital design tools must start to respond to the need of communication and translation between various stakeholders.

CONCLUSION

Today’s society is expected to be digitally involved: from Facebook and Twitter enabling social change to platforms such as Github (which allows anyone with the right skills to creatively contribute to the development of a software project), Peer-to-Peer networks and Bitcoin (a digital currency which exists as decentralised entity on all its users’ connected computers), and so on and so forth – the examples are endless.

Bringing together the non-modern context in which the design disciplines currently stand with the realities of the business environment reveals a complex web of interaction that requires careful articulation and negotiation. Creativity is not an isolated phenomenon under the exclusive rights of the designer, but a distributed quality that emerges from numerous interactions. As such, the role of the designer is transcending its simplistic understanding of “master builder” towards a “master negotiator” and an enabler of meaningful interactions.

It is in this context that, in order for a project to go forward, value needs to be defined collaboratively and as a shared sense amongst all the involved stakeholders. Current communication methods that are available to the architect rely on a notation that does not fully cater to these needs, and, as explained in the case study, sometimes can hinder it. Designers need to be able to orchestrate “a positive and spontaneous co-creative and emergent process” (Wood, 2007).

Digital tools have inherent qualities that have yet to be purposed towards these applications. We are already no longer designing finite objects, but rather processes that give birth to a set of objects. These “objectiles” are only defined by their network of interactions – of which, we, as designers, are in control.

Digital parametric models can go beyond aesthetic and technical exploration: they can embody a narrative and subsequently be the base of collaborative decision making. The flexibility of computational design can and should be used outside the architectural office and its technical collaborators. Nevertheless, we would like to end on a note of caution: “the choice of representation affects the process of design and should be understood prior to the creation and use of intelligent computational systems” (Sean Hanna, 2011). Tools can be used for good or for bad: a hammer can be used to build a house or to destroy an ancient statue, social media can be used to organise a legitimate protest or manipulate
people towards dubious causes. The responsibility of articulating a meaningful design is still in the hands of the agents enabling it to happen.

REFERENCES

ABSTRACT

This paper will explore the context and conditions for co-curricular live projects in architectural education at the Norwegian University of Science and Technology (NTNU), Trondheim. We have named it ‘NTNU Live Studio: beta’. In spite of their ‘global dimension’, live projects are local. They are anchored in the particular cultural, local and institutional setting that constitutes the very driving forces behind the student-initiated activities at NTNU. The challenges and opportunities of the NTNU live projects model will be discussed through three lenses: local conditions, learning outcomes and impacts on the profession and society. The discussion will be guided by this question: is a live project just a tool for learning and teaching, or does it hold strategic potential in contributing towards a transformation of student, teacher, profession and community?

The NTNU model applies a pragmatic aesthetic approach towards building, yet challenges the prevailing professional paradigms by acknowledging the societal forces calling for a different type of professional. We will be discussing not only NTNU Live Studio: beta’s recognition of the professional importance of practice, but also highlighting Live Studio:beta as an entrepreneurial catalyst for business and professional reorientation. The staff and students participating in live projects at the Faculty of Architecture act within a community of practice (CoP). This secures the balance between students’ freedom and project ownership on the one hand and the necessary academic and professional follow-up by the institution on the other. Research on Live Studio:beta is a work package in the faculty’s research program on transformative learning in architectural education, Transark.

INTRODUCTION

This paper presents the approach and acumen of the NTNU Live Studio:beta at the Faculty of Architecture and Fine Art, a program recently granted the 2015 Quality Enhancement Award from the Norwegian Ministry of Education & Research. The program emerged both in response to teachers looking for more relevant and thus more efficient approaches to learning and to the energy and engagement of students trying to circumvent the limitations of the traditional studio. There is a tradition and culture for Design –Build and Live Projects in the NTNU curriculum as well. This paper, however, concentrates on the co-curricular student initiated projects and program. NTNU Live Studio is organized as a dual model with a mentor hub and the student hub, hence Live Studio:beta.

The paper is based on written reflections from participating students over the last 5-6 years and our own experience as teachers. It ends up through an analysis of the student feedback in a set of new questions. These drive
at the institutional challenges relating to mainstreaming this approach both in educating professionals in general, but specifically in how to generating relevant insights and strategies for future architects to also actively engage with the economic and social challenges we all face.

The pedagogical-didactic approach in architecture education has for a long time been dominated by so-called ‘studio teaching’, i.e. simulation of architecture and planning projects in controlled learning environments sheltered from the social and material realities that confront all projects that are to be implemented. This approach is rooted in the Beaux Arts tradition, and deeper down in the mind-body dichotomy. Weaknesses in studio teaching have been acknowledged and discussed for many years. Bauhaus, for instance, was established in reaction to this approach. Frank Lloyd Wright, in 1931, openly warned against entering an architecture school “except as the exponent of engineering” (Kaufman & Raeburn, 1931/1961). Fifty years on Peter Buchanan wrote, What is Wrong with Architectural Education? Almost Everything (Buchanan, 1989). He sluggishly followed up 20 years later (Buchanan, 2011; 2012), so did Till (2009) and Skotte (2009; 2014) – and many, many others. Still, very little change has taken place. The reason for this institutional inertia may rest in the nature of academia and its power structures, but also, as Ivison and Vandeputte (2013) claim, in the present utilitarian, or neo-liberal nature of higher education.

The proposals by writers and alternative practices already applied at many schools all suggest that the present day challenges require not only new skills and knowledge, but also a new understanding of our professional role, a new concept of knowledge and new methods. It requires active dialogue, real interdisciplinarity and empowerment of users and citizens based on what Salama (2015) would label ‘trans-critical pedagogy’. This is what we humbly have been trying to abide by.

UNDERPINNINGS

We have to be honest, not merely academic. The NTNU Live Studio:beta program evolved over time, not as a resolute decision grounded in theoretical speculations. Several contingencies overlapped in time to ground the program within the faculty. New staff conceptualizing architecture in a more practical sense. Staff realizing the deficiencies in ‘studio teaching’ setting up alternative workshops. New and existing faculty programs adapted, or demanded, a more pragmatic and socially responsive academic approach. All this was taking place against the backdrop of students eagerly exploring the fields outside the ‘academic box’. It has been a reflexive process where insights gained through experience have affected subsequent strategies. Beneath it all was the realization that architecture constitutes a societal strategy, and ‘what’ students learn depends on ‘how’ they learn.

Since 2013 research on our Live Studio:beta experience is a work package in Transark, the centre for transformative learning in architecture education at NTNU.

Of course, we did not start from scratch. We were well aware of the extraordinary work undertaken by students at Rural Studio (Oppenheimer and Hursley, 2002; 2005), and the design-build programs already established at many architecture schools worldwide (www.liveprojectsnetwork.org). We had read some of the writings of Donald Schön (1987, 1993) and were at the time working with Nabeel Hamdi (2004). But most importantly, we were, through reflections on our own architectural and planning practice, drawing guiding insights onto our teaching. We were, in our humble way, trying to be ‘dual professionals’
where reflective practice modulated our academic contributions.

Juhani Pallasmaa, representing the phenomenological movement in architecture (Holl, Pallasmaa and Perez-Gomez, 1994), has been a guiding thinker in shaping our approach. His wonderful *The Eyes of the Skin* (2005) and *The Thinking Hand* (2009) highlight the role of our senses in understanding architecture. This bears heavily on the ‘how students learn’. Dagur Eggertson of Rintala-Eggertson Architects confirms having said that “only when you have carried stone, do you understand how to use stone in your buildings”. This leads us on to the power of embodied cognition. Neuroscience has uncovered how our senses generate understanding, i.e. affects our cognition directly without filtering or abstracting it through our brain. It is a discovery especially important in architecture in that its very nature is material yet experienced and appreciated through our senses (Mallgrave, 2013; Robinson and Pallasmaa, 2015; Skotte, 2009; 2014). This is actually how the built environment makes sense to people, if not to architects. Because, as Aravena says, “Nobody cares what architects do, only other architects” (Aravena, 2011).

This sensory experience is at the core of John Dewey’s approach to learning, or rather, the transformation of the experience into insight or knowledge. The process of transformation is hinged on reflections. Dewey never propagated a ‘learning-by-doing’ approach. What he claimed was “We do not learn from experience... we learn from reflecting on experience”. (Dewey, 1916). Not reflecting is not experiencing. It is like being drunk on sensations. Reflecting represents “slow learning”, according to Archipovaite (2015). It takes time to reflect on what you have been through, on what you have learnt or understood, not least in relation to other people and society at large. This is where Dewey links education to democracy and thoroughly debunks the notion of education being teachers filling the empty “knowledge sacks” of students. Instead, he sees education bringing about inquiring students. Much the way Hanna Arendt saw educational excellence, according to Sennett, “A good teacher imparts a satisfying explanation; the great teacher – as Arendt was – unsettles, bequeaths disquiet, invites argument” (Sennett, 2008).

The power of reflecting, or the effectiveness it holds on learning, is exhaustively presented in a recent Harvard Business School Working paper (Di Stefano et al., 2015). The authors make due reference to Kolb’s (1984) four stages of learning, grounded in 1) experience, 2) by reflecting upon it, 3) forming abstract concepts, and 4) building insights. They also refer to the efforts of codifying tacit knowledge through reflections, a hot issue within architectural circles. Architects, or any particular profession, it is often claimed, hold knowledge outsiders cannot fathom because it is non-verbal and belongs to the profession alone. Polanyi (1966), later also others, claims that reflective efforts of untangling tacit knowledge gives a deeper understanding of its properties. This claim is further strengthened through the findings of Daniel Kahneman and his two systems of thinking; the omnipotent System I (intuition, tacit knowledge, spontaneity) and the ‘lazy’ system II (critical reflection). We live by the first, but insights and knowledge necessary for societal progress stems from system II (Kahneman, 2011). Most significantly the Harvard working paper for the first time empirically shows “that the capacity to reflect on action improves learning” (di Stefano et al., 2015). Formulated slightly differently, and based on qualitative investigations, Donald Schön set forth theories on how professionals, including architects and planners, reflect and thus learn in action as a matter of course, and how students may learn to by engaging with those more experienced (Schön, 1983; 1991). This leads directly to the notion of “communities of practice”, where “groups of people who share a concern or passion for something they do and learn how to do better as they interact regularly” (Wenger, 2006). Students and teacher can in the best of cases constitute such a community, the authors of
this article definitely make up one, and engaged student groups do. The relevance to the Live Studio:beta program is that the intra-action of these communities, i.e. the engaged student groups, act as a living curriculum as it acknowledges the role social structures play in learning with and from each other. We may also see them as arenas for horizontal and thus extra-curricular or autonomous learning.

What characterizes these communities of practice is that they acknowledge the plethora of components or properties a community consists of and depend upon, its complexity, so to speak. This brings us to our last and perhaps most important buttress of the Live Studio:beta underpinnings, that of the theory of simultaneities. The term refers to “events or phenomena that exist or operate at the same time” (Davis, 2015) better illustrated, perhaps, by conceptualizing the knower as inseparable from the knowledge he holds. Again, we are debunking the image of the “knowledge sack” of the learner. Education, and learning, is thus always dealing with the knower-knowledge duality - simultaneously. Even though knower and knowledge can be considered separately, they cannot be considered separate. There are numerous claims in the complexity theory in which the notion of simultaneities is embedded that point toward the NTNU Live Studio:beta praxis. The tension or balance between attention to and ignorance of detail echoes Nabeel Hamdi’s warning to our students “Don’t think too much before you do, and don’t do too much before you think.” Another one would be taking responsibility for the externalities of your doings, because these consequences are there - embedded as it were, in the project.

As we shall see in the next section, our empirical material and feedback from students is a throwback to the explanations given by the writers above. We are still in the process of distilling our experiences into theoretically grounded claims. Remaining honest, methodologically we realize we are within the realm of Grounded Theory (Glaser and Strauss, 1967), but it is an approach we have not yet pursued theoretically. We will.

WHAT WE DO

NTNU has a long tradition of students undertaking ‘live projects’. Many schools of architecture do. What sets our projects apart is that they are generally initiated, organised
participation

and managed by students themselves, not faculty. The ‘live projects’ have varied from small traditionally crafted boathouses on the coast of Norway to large community development plans on other continents. Students apply a context-based design approach whereby they have to work closely with members of local communities, municipalities, professionals, contractors and other stakeholders. This collaborative nature is what allows the projects to take flight.

the organisation

NTNU Live Studio:beta makes up a common platform with two nodes, one for faculty and one for students (figure 1).

This ensures the independence of the students, yet opens an arena for negotiations on academic, practical and social issues between teachers, students and involved partners, most notably through the monthly ‘Live Studio:beta Roundtables’ established for strategic discussions and exchange of experience and reflections.

The student node, Studio:Beta, organizes students into what over time becomes a “community of practice” (Wenger, 2007) through joint discussions and guidance on each other’s projects (peer discussion and mentoring). This also ensures stability and robustness through common social practices and recruitment.

The faculty node also forges a ‘community of practice’ among engaged staff and external consultants by ensuring that insights, reflections and lessons learned are gathered, processed and relayed through learning materials, guidance, and coaching. Academic quality is secured by teachers and consultants acting as ‘mentors’ of the various projects. Over time, this has forged structures that ensure stability and thus enabled the participants to mature into “Dual Professionals” (i.e. simultaneously be and act as professionals and teachers) (Beaty, 1998).

Each project is organized separately, defining participating students, engaged mentor[s] and consultants. Planning and the required measures to ensure implementation, i.e. cooperation with local suppliers, engaged interest groups, local and national public bodies – and often sources of funding, are all organized by the students, and are seen and experienced as an important part of the learning process. Projects abroad are always undertaken in close cooperation with local organizations and local authorities.

emerging reflective practice

The reflective practice in learning entered the Live Studio:beta program from an international NTNU master course in ‘urban ecological planning’. Through regular reflection papers the students documented their growing insight both individually, pertaining to group work, but not least their understanding of the context. We have continued the practices of students writing weekly feedbacks in the Live Studio:beta projects ever since. The importance of this practice cannot be overestimated as it gives us empirical evidence as to what students actually learn – which we all know is different from what the grades tell us. What follows rests squarely on student reflections. We have grouped them under two broad headings, Mastering Constraints in and of Practice, and Social Sustainability.

mastering constraints in and of practice

Working with real people and real impacts bring all kinds of challenges the students have never had to deal with before. “What we did was real, important and true.
Unfortunately, this is a feeling I have never had at NTNU" (student, 2009). Reality calls for skills in communication, interpersonal trust, adhering to time schedules, funding limits etc. Even though students are exposed to and simulate some of these skills in their studio environment, whereas through Live Studio:beta they are acknowledged learning opportunities, not merely sources of despair or frustration. As one of the students stated: “For me, it’s essential to be able to work ‘live’, in collaboration with others, and with high complexity and short deadlines. That’s how I become creative” (student, 2015).

**PROJECT MANAGEMENT**

How much does a wall cost? What do we do first, the wall or the roof? How do you regularly inform your partners? These are the types of questions students raise when leaving the studio and stepping onto the building site. When going ‘live’ they face challenges they did not even know existed, and that are not even visible in the finished project. Their notion of what architecture is gradually changes through the experience of practice:

“We spent all our time making phone calls, writing emails to manufacturers, negotiating with the municipality, doing budgets and even talking to the local newspaper. We agreed that next time we had to focus on the “architecture”. Of course, now I know that the “architecture” was what we did. It’s worthless to have an idea or vision if you’re not able to build it, negotiate it or finance it. And that’s why I think it’s extremely important to do projects live, because what we learn in studio projects maybe only make up 10% of our [the architects’] daily work” (student, 2014).

The crucial importance of budget limitations, building logistics and progress plans etc. suddenly opens up a completely different world for the students: “A thin budget challenged the design of the project, but it generated innovation and creativity” (student, 2014). Others developed entrepreneurial skills:

“We needed to generate a project from the very beginning, coordinate all the involved disciplines, make all the decisions and adapt the project to the limited budget we had. In the end, we founded a non-profit organization that took care of the operating expenses of the pavilion” (student, 2011).

Again, we see students experience – and hence learn, that a problem and its perceived solution changes as they start working with it.

“When playing along with the limitations, you’re more likely to find a good answer. But this skill requires training, and I suppose that’s why we have architecture schools. If you go through architecture school without facing any real-life constraints or problems, you will base your choices of intuition only, and the designs will be artificial and lofty. They merely build up your ego” (student, 2015).

**COMMUNICATION**

The studio environment does strengthen the students’ skill in communicating – but only to other students, teacher and examiners and hence tend to become tribal-speak. In a ‘live’ situation, the audience is calling for a much wider communication repertoire. More like what professionals face in their daily line of duty. This is how one student comments on the issue:

“Why do we [architects] complain of not being taken seriously? Why blame the others? Have we forgotten that we should be communicators? Have we forgotten
that we are translators? [...] If there is a discipline that appeals to the general public, it must be architecture. And yet we remain the experts that no one understands” (student, 2014).

In preparing for presentations and negotiations with people outside our profession, e.g. lay people from the community, the students also have to clarify the issues among themselves. No chance of using tribal ‘archi-speak’:

“When we had visually communicated the information we had gathered to the community, did it become clear to us what our project could become. We showed the barangay council something that proved we had invested time and efforts in understanding the area [...] . I believe this was significant in gaining their trust and being met with enthusiasm in the meetings that followed” (student, 2014).

**HANDLING RESPONSIBILITIES**

The students have to shoulder serious responsibilities when building real structures in an open society. As the students wrote in the NTNU Live Studio:beta Handbook: “Stepping on someone’s studio project model may cause some tears, but the outcome of the roof flying off a building during a storm is far worse.” Taking risks and responsibilities challenges the conventional students’ role. The live projects represent a reality check on their decisions and their consequences, (and again we see the link to the notion of simultaneities):

“I have gained a unique understanding of the gravity our choices hold once it will affect a building that will exist for years to come. How incredibly important it is to make right choices when the stakes are so high, not only for me, but for all the others. This is something we never experience in a studio situation” (student, 2014).

**TEAMWORK**

In live projects students hardly make decisions alone. This will sometimes make things easier, but working in Live Studio:beta teams seem to require other sets of individual skills than those expose to or trained for in a studio environment. In live settings, the team has to deal with new complexities, personal responsibilities and the fact that other stakeholders are now part of the team. All this under the threatening time pendulum.

“We think that collaborating with a local carpentry workshop is very beneficial for architects. The fact that we could sketch a solution together, and go straight to the workshop and try to make it in full scale, was a liberating feeling for the whole team” (student, 2011).

Working in a live project team may expose the members to different perspectives. This may become its strength.

“The experience of building together, particularly with Intit (our hired ‘professional’) challenged our understanding on how they do things, and equally challenged him to understand what we were up to” (student, Philippines, 2014).

Teamwork makes all collectively responsible for the result. This can also be threatening – and often frustrating. As one of the student demonstrates:

“One has not really experienced teamwork until, after ten days and 150 man-hours, we still argue about a window. Should it stand in the middle of the wall, or 10 cm off centre? One must, in a group, dare say what one thinks. One must stand for
what one believes is right, but one must also endure compromises. When ‘in flow’ teamwork is a delight. In adversity it is hell” (student, 2014).

Any experienced architect would recognize the statement.

PARTICIPATION AND OWNERSHIP

Live Studio:beta project always involve others, not only students. These are ‘real people’. They are in most cases ‘clients’ and will be the ones who will care for and maintain what the students leave behind. In order to make the projects long lasting, or ‘sustainable’, it is important to build a true sense of ownership around it. In order to achieve this, the students have to stand back. The locals are the ones who know what makes the community tick, a requirement for securing the future. Hence it is not about “letting” stakeholders participate, it is about acknowledging their insight and making sure it informs the project in order to make it ‘theirs’, and it must be theirs in order to make it last. One of the student state:

“A question I think everyone has to ask themselves when working with so-called “participation” is whether one adheres to a call for participation and ownership in itself, or whether one also takes hold of the knowledge and experience that comes forward, and let it shape the project. Throughout the entire process this was a recurring challenge” (student, 2014).

Throughout the years, and particularly amongst the students working abroad, these questions are constantly raised in their reflections. Opening up, standing back, critically examining your own references, but relating to, and learning from local knowledge is part of the prescription the students give in realizing and securing the future for their projects. “The open dialogue depended on trust and respect for each other. If I thought we could have done without their contribution, we would not have taken their input so seriously. But we depended on being able to transform their words into important factors for the project” (student, 2014). Another group states a similar approach:

“As architects we tried to process the thoughts of the users into good and user-friendly architecture. It was important that people who were involved in the process could recognise that our discussions have had an impact on the finished project. […] Our work with FRIrom has made us see our discipline in a new perspective. In addition to being architects, we worked to inspire commitment, and give ownership to the leaders of the hospital, the clinics and the potential users” (student, 2011).

THE LEARNING PROCESSES

“The main reason for going was the opportunity for learning. However, it was vital that our work was relevant for a society that is still recovering from the devastation caused by typhoon Haiyan. Learning and doing useful work were parallel throughout. We believed that more meaningful work would lead to better learning opportunities as well was helping people less fortunate than ourselves” (student, Philippines, 2013).

We have throughout subscribed to the notion of knowledge emerging from discoveries. As a member of a student group going to Port-au-Prince after the earthquake 2010 did:

“Learning new things often means jumping into deep water - trusting you will find ways of getting back up. You can always prepare yourself better, you can always seek more information, study and learn more before you jump, but when is the right moment to jump?” (student, Haiti, 2010).
It is to be noted that he made a first-rate return to dry land. This is at the same time an exquisite presentation of the notion of liminality in learning, i.e. the passage through a ‘uncertainty-phase’, a liminal zone that once passed generate new understanding (Meyer & Land, 2003).

**CONTRIBUTING TOWARDS CHANGE**

When the Ministry of Education & Research gave us the 2015 award for Norway’s best university program, they forecasted its educational potential being applicable also to other disciplines. They did not, however, give us the answers on how to transfer and transform its qualities. The biggest challenge now is how to adapt and implement this educational approach to other fields of the university and, furthermore, how may this affect its teaching and learning environment? To respond we have to dig further into the students’ reflections.

What emerges is the notion of ‘negotiation space’, a fusion of context and content of the Live Studio:beta projects. This discussion is meant to map the space that NTNU Live Studio:beta holds between students and university. How is this space formed? What impact does it have? How may it influence and contribute to the broader university-learning environment? These question marks indicate the uncertainty of our position as this space is not given or defined by any one rule. When re-examining the student reflections, four main domains shape our experience: Practice, Ethics, Society and Theory. These four domains hold the negotiation space of the projects (figure 2).

The negotiation space of the platform or the program holds a distinct set of domains as experienced students, now members of a true community-of-practice, are drawn into the negotiation space of the platform. These negotiations take place between mentors, the Faculty and experienced Studio:beta students. Student, Learning, Education & University are the active domains creating another set of simultaneities and (fruitful) tension (figure 3).

This culture of constant negotiations is a key characteristic of the NTNU Live Studio:beta approach. There is adaptable space for negotiations in every project and within the organization as well, all defined by a given context and its given limitations. All in line with
Alejandro Aravena’s claim that creativity sparks from constraints, e.g. where “there are rules, you have freedom” (Aravena, 2011) These negotiations create the unique type of ownership that has proven to be such a central part in formulating future scenarios of Live Studio:beta.

INDEPENDENCE AND OWNERSHIP

Community of practice (Wegner, 1998; 2011) is embedded in the nature of all live projects. The students are bound to find ways of helping each other and work together. This sense of mutual trust, and constant negotiations, also include the mentors. This ‘responsible independence’ creates a sense of ‘ownership of process’. It has come to be the very keystone of Live Studio:beta.

Live projects attract particular kinds of students. Even though self-confidence is at the heart of the Nordic democratic (school) system, live projects are not the main choice for all. The ones that join are driven by curiosity of the process and the project and are willing to take the risks and responsibilities this entails. The acquired sense of ownership cultivates not only independence, but also demands an ethical stand towards the third person or to greater society. These are powerful learning processes and it is obvious that they will affect the students’ understanding of their future role as professionals.

Extra- or co-curricular projects represent a major institutional challenge. It has to do with funding. Projects undertaken outside the regular curriculum do not generate ‘financial faculty credits’, on which basis funding is disbursed within the university. Yet, the faculty covers the salaries of mentors and fees to consultants and sometimes give financial support to projects. They still do so because of the proven learning efficacy of the Live Studio:beta activities. To proceed we have to resolve this issue – most likely on a university level.

LEARNING THROUGH REFLECTIONS

The sense of ownership does not stop with projects and processes. The students start to take ownership of their own learning processes. Reflection processes have come to take an important role in the Live Studio:beta learning program. Reflections require “concrete experiences” according to Kolb (1984). The processes linked to projects and platforms are such sensory and cognitive processes where students through reflections go “from
learning by doing to learning by thinking” (di Stefano et al., 2015). At this point the role of learner and teacher becomes more interactive, communicative and collaborative. We are into the type of learning environment Ashraf Salama talks about where “Learners identify problems and resources with the aid of teacher-facilitators; they learn to develop problem solving tools and techniques as well as set standards for solution, and work with both the abstract and concrete” (Salama, 201).

Students’ reflections and observations by the staff and through the Transark research initiative show that managing risk, taking responsibility and acknowledging being vulnerable are held as essential driving forces in the learning process. This also shapes the negotiation space of NTNU Live Studio:beta. Reflections are processes of abstraction, of theorizing, so to speak. Reflecting in a state of vulnerability or uncertainty is the start of theorizing, to understand the domain of Ethics/Bildung and Society. All the while getting closer to the core of architecture.

Through these learning processes the students start positioning themselves in the world of architecture, much in line with Snodgrass and Coyne (2006): “architecture is interpretational in so far as it involves positioning. To position something is to invoke a primary architectural moment. To be positioned is also to hold a point of view, an interpretation, or is perhaps the start of an interpretation.”

END NOTE

The overriding message rising from NTNU Live Studio:beta is linked to the ownership issue, the negotiation space, the mutual trust within the community of practice – and embedded complexity (figure 5). The existing educational approach in architectural education (figure 4) will not be able to meet the challenges of the future, not even today’s complex reality. The world will undergo dramatic changes and we thus have to focus on releasing the creative potential of our students. We have to ensure that their education will foster appropriate “knowledge for a better world” to echo NTNU’s vision statement.

Experimental education programs are required to move into an unknown future, a claim supported by Ashraf Salama: “Effective learning - oriented towards collective problem
solving depends upon reflections, discourse, and experimentation” (2015).
The experimental nature of NTNU Live Studio:beta was given due recognition by The
Norwegian Ministry of Education & Research by bestowing the award on the program.
They acknowledged the value in its alternative approach in university education. In an
interview with Dezeen after receiving the Pritzker Prize, Alejandro Aravena elaborated on
the education of architects and sums it up by simply stating that “We’re never taught the
right thing at university.” In our small way we try to do the right thing.

REFERENCES
Archipovaite, E., 2015. From the Studio into the Field -’Slow’ Learning and Teaching in Context. Charrette,
ac.uk> [Accessed 12 December 2015].
Beatty, L., 1998. The Professional Development of Teachers in Higher Education: Structures, Methods and
Bell, S., 1998. Self-Reflection and Vulnerability in Action Research: Bringing Forth New Worlds in Our
185(1109), 24-26.
Available at: <http://www.architectural-review.com/home/the-big-rethink/the-big-rethink-part-9-rethinking-
arhitectural-education/8636035.article > [Accessed 8 December 2015].
Dezeen, 2016. [online] Available at: http://www.dezeen.com/2016/01/13/alejandro-aravena-interview-
Education>, [Accessed 9 December 2015].
Harris, H., & Widder, L. (Eds.), 2014. Architecture live projects: Pedagogy into practice. United Kingdom:
Routledge.
Research, Chicago: Aldine Publishing Company.
Hamdi, N., 2004. Small change: About the art of practice and the limits of planning in cities. United Kingdom:
Earthscan Publications.
Ivison, T & Vandeputte, T [eds], 2013.Contestations; Learning from critical experiments in education, London:
Bedford Press
Meridian Books.
Cliffs, NJ: Prentice Hall.
Mallgrave, H. F., 2013. Architecture and embodiment: The implications of the new sciences and humanities
and practising within the disciplines. Edinburgh: University of Edinburgh.


Living architecture: currencies between architectural pedagogy and time-based media performance

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INTRODUCTION

The rise of pervasive computing (Weiser, 1991) and networked technologies has resulted in a hybrid structure of Mixed Reality Architecture (Schnadelbach et al., 2007; Benford and Giannachi, 2011) and Augmented Environments (Aurigi and De Cindio, 2008). This offers ‘new tools’ that may modify our perception, and even alter our bodies. Human bodies can be used for all sorts of cognitive purposes, not just to act on the world or co-create a personal world, but also to represent, model, and ultimately self-teach (Kirsh, 2013). Accordingly, human bodies can be used as simulation and modelling systems that make it possible to project to unseen things that would otherwise be more inaccessible. The rapid development of ‘digitally mediated’ interactions and the use of sensors designed around the body (such as in wearable tech) changes the way the human body relates to its responsive and potentially interactive surroundings. Arguably, this new development promotes new modes of engagement with older questions, it influences the way to prepare architects for new challenges in the field and calls for providing new tools and methods to be incorporated into the architectural education.

In this paper, I describe my research-based teaching for the unit ‘Embodied and Embedded Technologies’ on the Architectural Computation programme (MSc/MRes AAC) at The Bartlett, UCL. The unit consists of two modules exploring sensory environments and ‘digitally mediated’ interactions in Media Architecture and Urban Digital Interaction.

I present an attempt to foster new ways that extend beyond traditionally applied modes in architectural education and Human Computer Interaction (HCI), through integrating space, the body, digital media and computation in a module taught to students coming predominantly from architectural design background (Fatah gen. Schieck, 2012). The teaching adopts the design studio culture, which integrates: teaching, discovery (research), and application (practice). It draws on my research that intends to build a collective of researchers and practitioners spanning design, interactive technologies and media and the performing arts and applies a multidisciplinary approach where architectural space, the body and body movement, interaction design and performative interactions (Salter, 2010) come together. The teaching starts in term one with exploring the body as a design material in the ‘Body as Interface’ studio; and extends in term two towards the city context in the ‘City as Interface’ studio, which engages with the social agenda and the various aspects of participation in the networked
PARTICIPATION

city. In the paper, I focus primarily on the ‘Body as Interface’.

Donald Schön’s concept of the ‘knowledge in action’ and Kirsh’s concept of the ‘thinking with the body’ provide a useful framework for interpreting my approach.

MEDIATED SPACE AND THE EMBODIED EXPERIENCE

Conceptual ordering, spatial and social narrative are essential to the way we design and experience buildings (Psarra, 2009). Buildings are defined through a thinking mind that organises and creates relationships between the parts and the whole and they are experienced through use and movement. We use our bodies to move, navigate and communicate, and change our posture relative to the space we are in, and the people around us.

At the heart of the 21st century, ‘interactive’ and increasingly ‘adaptive’ architecture will become part of our experience, forming an important shift in rethinking the public space and its social importance. With the new development, digital media extends into the physical and temporal aspects of architecture, creating visual and auditory interaction spaces. These spaces enable various types of embodied experiences as we interact within a shared space, which, in turn, may motivate new social interactions or disrupt the habitual nature of everyday interactions, creating new stages on which people can play out a variety of engagements. People are no longer limited to the role of the spectator or passive actor but are rather active in defining the emergent mediated collective experience.

Interactions with and through technology are performed with a variety of bodily situations, by being present at a location, for instance, or through movement. Research areas are merging, such as architectural design, HCI (Human Computer Interaction) and interaction design, which can be considered as a discipline of movement practice (Larssen et al., 2007). Several design approaches seem to emerge that support explicit bodily involvement by designers as part of the design process “if one truly likes to design for movement-based interaction, one has to be an expert in movement, not just on theoretically, by imagination or on paper, but by doing and experiencing while designing” (Hummels, Overbeeke and Klooster, 2007). In the learning environment, however, research into the design and development of digitally mediated environments and the way it is supported through full body interaction, is less considered in the academic arena.

As we find ways to incorporate digital media and computation in architectural teaching we need to rethink the role of architectural education. We need to develop new ways that extend beyond conventionally applied methods, which may in turn, challenge the traditional teaching model, and support re-inventing it as a mediated social and spatial experience. I argue that in order to capture, respond and regulate people’s experience, understanding the body and body movement, as a design material is key. The body sense of space is a combination of many sensory inputs including visual, kinesthetic, auditory and olfactory. In this sense, looking at the space-in-the-body (Laban and Ullmann, 1974) in addition to the body in space, postures and gestures will open up the possibility to better understand behaviour, and body movement and to develop new ideas and principles about spatial experience and interactions.

From the Human Computer Interaction (HCI) perspective, and as our experiences are increasingly mediated through tangible digital technologies (in different forms situated, mobile and networked), it is said that the theory of embodied cognition (Kirsh, 2013) offers new ways to think about bodies, mind, and technology. Accordingly, body movement can
literally be part of thinking, as a distributed and interactive process. Making a substantial change in the body might literally affect how we think; when we interact with the world we begin to simulate processes that shape our internal anticipations of how things may turn out. This is done through a form of implicit cognition buried deeply in our perceptual system. But it results in changes in how we mentally simulate the future. Moreover, by exploring how we think through things, designs may draw upon our embodied, distributed, and situated cognition, our ‘physical-digital coordination’. In other words, communication is not only media specific, but also body specific. According to Kirsh (2013), embodied cognition can provide us with new ideas and new principles for better designs as:

“(1) interacting with tools changes the way we think and perceive – tools, when manipulated, are soon absorbed into the body schema, and this absorption leads to fundamental changes in the way we perceive and conceive of our environments; (2) we think with our bodies not just with our brains; (3) we know more by doing than by seeing – there are times when physically performing an activity is better than watching someone else perform the activity, even though our motor resonance system fires strongly during other person observation; (4) there are times when we literally think with things”

In the following section, I describe my teaching approach, in the ‘Body as Interface’ studio, which focuses on the human body as a design material and builds on lessons from time-based performance pedagogy. I then outline aspects highlighted through students’ projects followed by qualitative feedback from this year’s students, before finally drawing conclusions about the light this approach throws on the nature of the body-based design process and the explicit bodily involvement by designers as part of the design process towards time-based architecture.

THE BARTLETT’S ARCHITECTURAL COMPUTATION PROGRAMME

The AAC is a one-year taught course in the field of Architectural Computational design, and has been running since 2005. The programme (MSc/MRes) engages with the main technologies by which tomorrow’s architecture will be designed and constructed. It perceives computation as a technology driving fundamental shifts in industry and society, and, more radically, one that can change the way we create and think. Students are educated to do research, in the context of industry and practice, to change the way built environment is designed, constructed, and inhabited. To this end, the learning of technical knowledge such as computer coding plays a stronger role than in many comparable courses, not only as a skill but as a framework for thought, which is supported by a broad theoretical understanding of algorithms and philosophies of artificial intelligence and related domains.

These digital tools and design environments provide, among others, increased levels of investigation at micro and macro scale that can be considered in parallel and at multiple accessible stages of the process, which in turn, increases the ability to abstract, a key skill in design (Morton, 2014). However, the focus in the design process on the coding and the computational framework of thinking, coupled with the reliance on visual reasoning and visual relationships of design elements, may raise a question as to whether design is thinking or doing. Furthermore, this could lead to over reliance on virtual digital tools with little understanding of what the digital model is expressing, in particular when it relates to embodied and time-based interactions. To train tomorrow’s designers – I argue, this framework needs to be balanced through a time-based embodied approach. Here, I believe, it is essential to support an iterative learning ‘loop’ of thinking, doing and feeling,
which is key to acquiring knowledge, and forms a fundamental part of the learning and reflective feedback (Schön, 1987).

In this respect, the design studio culture can give the students a hands-on opportunity to create spatial prepositions. Combining computational sketches, sensing and actuating mechanisms that are supported through embodied approaches, will offer an opportunity to learn from the artefact and to close the loops between the design and the outcome. The students are assessed formally, at the end of the process, by giving an audio-visual presentation in action through film, and multi media and a demonstration of a time-based installation activated through a whole-body experiential response.

RESEARCH AND TEACHING: EMBODIED DESIGN THINKING | THINKING WITH THE BODY

There has been interplay between my teaching and my research; an interesting aspect of the approach I present here (and also a challenge). One line of my inquiry explores Media Architecture (combining architectural space, interaction design and choreography) with the focus on the body and the dynamics of the moving body, and how this relates to the design of our affective experience, and digitally mediated situations. I explore this through my scholarly work, and design projects resulting in creative installations and publications. I engage with new modes of learning in architectural education through my studio teaching activities. I believe linking my research and teaching is valuable because it encourages the students to explore and present their own interpretations on the theme, which is an essential part of the whole process. Through engaging with my research the students gain first experience with embodying space and the use of different methods to translate this and create their own experimental interpretations. It is also important to bear in mind that teaching and research may require different kinds of spaces and they may not serve to enhance each other (Rowland, 2006).

The proposed approach, however, differs from traditional architectural education, in that the project is typically created and implemented in the real world setting, and requires applying a range of methods from interpretative-ethnographic to time-based experimental approaches. It emphasises the emerging nature of this new field, and encourages the
students to be active participants in the learning experience and shaping the final outcome.

I have been involved in the AAC programme since its inception, and my approach in developing the teaching is based on action research. I have observed throughout the years how students respond to the various computational methods and thinking-centered framework applied within the AAC course. This was coupled with my reflection on innovative work in the research group for developing an interactive dance-architecture (a conversation between dancers and dynamic digital simulation). The starting point, however, was prompted by the collaboration with a dance choreographer to carry out the first body-centred workshop (2008) and was reinforced after attending a week of intensive workshop and the exposure to a fascinating world of practice focusing on the moving body and the geometry of space through the lens of Rudolf Laban’s principles. This training was an eye-opener, and have provided me with essential concepts and a main framing, which has to a great extent informed my approach and my understanding through ‘feeling’ space.

The ‘Body as Interface’ studio is supported by a variety of teaching modes, including the general course workshops (Physical Computing and more recently Robotics), seminars, and group tutorials. In the following, I explore the core workshop i.e. the ‘Body as Interface’ workshop.

THE WORKSHOP: EMBODIED AND EMBEDDED TECHNOLOGIES | BODY AS INTERFACE

With an emphasis on the body as a design material, the studio is supported by a body-centered training workshop aiming to encourage students to rethink the relationship between the human body, behaviour and its architectural setting in particular, as it is increasingly framed through time-based digital experiences. We apply a multidisciplinary approach where concepts of architectural space, body movement, performance, improvisation, and interaction design come together - drawing together, over the years, a broad range of collaborators in the filed of dance and performance, visual arts, choreography and Human Computer Interaction.

The overall intention is to raise awareness of how kinaesthetic perception uncovers different properties than visual perception. These kinaesthetic properties, and the way they are encoded, make it easier to recognise the validity of interpretations that would be near impossible to infer from vision alone, if one did not also move the body (Kirsh, 2013). We utilise dance training methods such as Laban and Forsyth's improvisations techniques encouraging experiential learning through whole body interactions, curiosity, and participation. More specifically, the approach intends to open the body and mind, break routines and rethink various aspects that we take for granted. The premise is that to design for movement-based interaction only through movement, and through practicing the movement, the idea can actually be understood. By engaging the body to help cognise (Kirsh, 2013), the participant is able to understand the possibilities of movement better than observation of someone else doing it as she acquires participant knowledge.

Through practical physical exercises led by dance practitioners, students make good use of their different senses, as our senses pick up different information, and gain understanding of how we embody space and focus on practical aspects related to space orientation / gravity organization.

Aspects of movement and sensing space, in terms of its spatial content (space-in-the-body), are explored with the aim of developing a dynamic moving body, conscious of personal
space and aware of spatial relationships between bodies. Key elements of movement communication are introduced such as posture, gestures in conversation, and the notion of ‘proxemics’ and sensing ‘proxemics’, which represents the use of micro-space. In this respect, the interaction and perception in specific situations is framed through culture including the relationship, activity, and emotions present in a given situation (Hall, 1966).

To date, 8 different workshops were carried out. The workshop format has evolved over the years initially running for half a day (attended by 14 AAC students) with introduction to the main body-related concepts and has extended to a weeklong event (attended by 20 students from the AAC, the Place Centre for Contemporary Dance and the Slade School of Fine Art). The workshop combined, theory of body movement and perception, practical sessions and hands-on development and implementation of spatial propositions with simple digital manifestations.

Following the workshop, each student starts working on his/her own studio project building on the design material generated during the various exercises and the experience of the dynamic body in space. The students attempt to create their own experimental interpretations manifested through time-based installations. Body movement and spatial representation were explored through a variety of studies using different methodologies. One of the projects, for instance, created an installation that explores spatial interaction projected on a 2D plane and looked at how different types of the perceptual categorisation of space by different people would produce different ways to occupy and relate to the architectural space.

It attempts to find ways to represent the personal kinesphere (i.e. the space surrounding the body or the movement space), and to explore the relationship between space awareness, perception and body movement; how people relate to their own space and how they relate to other people.

One study tested the possibility of changing the eye location to a different part in the body, and how this affects the way we move in space

Another study explored designing sensory relations with the surroundings. It draws on
Figure 4 adaptable space generation - spatial perception and bodily action operate interdependently (developed in an interactive project using computer vision and processing - AAC 2010).

Figure 5 what if the human eyes are in a different location? How would this affect the way we move in space? This idea was tested with the use of a mobile phone and a camera that was mounted on different positions to provide vision mechanism for a moving body - AAC 2015.

Figure 6 a way of looking at the role our haptic and kinaesthetic senses play in experiencing tangibles (above) - AAC 2015 and the production and visualisation of different body signatures through spatial drawings in 3D space using hands and feet by four different people (using Kinect for depth sensing and processing programing language - AAC 2011).

Figure 7 experiments with whole-body time-based interactions with museum objects (depth-sensing camera captures the person’s posture and position in space - AAC 2011).
gestural data to explore the rich, interpersonal, non-verbal communication we read, and perform every day and the role our haptic and kinaesthetic senses play in experiencing tangible digital objects in space.

Playful interactions through full-body manipulation of museum objects was developed using depth-sensing camera to captures the person’s posture and position in space.

Finally, an interesting example, exploits full body movement with different ranges of interactions in order to develop a new tool for motion studies, where the outcome depends on the speed of the moving body. This was achieved through a reflective process of ‘thinking with the body’ using the hand, partial and full body motion over multiple iterations performed with the bodies of the students themselves.

In summary, the students’ work demonstrates aspects of gaining higher awareness of ‘Experiential Bodily Knowing’ [Larssen et al., 2007a] and understanding of the importance of the body, how it relates to its own space and to its surroundings. Going through bodily activities enabled them ‘as designers’ to perform movements, which can extend beyond their bodies to the objects they interact with, and into the way they design time-based interactions with digital prototypes and spatial interfaces. I believe, this offered valuable insights into how interaction with new environments, or interfaces, can frame the design of future experiences.
THE LEARNING EXPERIENCE

An important aspect of the teaching approach presented in this paper, is that students are encouraged to be active participants in shaping the learning experience. We achieved this by framing the students’ core experience around the body combined with the expression of movement, and exploring how our bodies create relationships with things around us and how the design of mediated experiences might ‘feel’ like.

My initial observations indicated that this approach has helped the students ‘feel’ the relationship between the body, space and mediated interactions and ‘think’ more critically about it, instead of relying on passing knowledge. It provided tools for design that extend our understandings of bodily aspects of ‘technology supported’ interactions and offered the students a deeper understanding of the role of the body and the space generated through body movement and the dynamic spatial relationships between bodies, which in turn, helped shape their project development and its direction.

This year, the students were asked to provide feedback through email about the learning process and their experience during the ‘Body as Interface’ workshop and to outline aspects that influenced the development of their studio projects. Five students responded (out of 8 who were registered for the studio). These comments must be considered only as preliminary and a part of an early development process, however, they proved to be very useful in helping us to develop appropriate techniques for future workshops, and the teaching in the studio overall.

Students’ feedback indicated that they have particularly enjoyed the body-focused collaborative activities as it challenged the way they used to do things and provided them with a new lens to view body-space related relationships:

“The body class was inspiring to me largely in its success in getting me out of my comfort zone… it gave me a good understanding of the ways in which we can use our bodies within defined spaces and the discussions we had made me think about the ways that architecture and sculpture are only relevant in terms of the human body… The body as interface is a concept about which I had not thought in the ways we were encouraged to do through these sessions. I found it a positive and thought-provoking…”

Other comments highlighted the importance of being in the action, rather than only observing it: “It was also interesting how computation can be so physical and human. How we explored the space was also liberating, it is generally a rare occasion that we get to play games with our body.” In this respect, it was important from the teaching point of view that we provide our students with the opportunity to engage in ‘real fun’, whilst practicing the new concepts and skills.

The role of the so called the ‘feel dimension’ (Larssen et al., 2007a), as a particular kind of dialogue between bodies and things, was highlighted, where people have different possibilities for action depending on their bodies, which in turn, opens up a new design space of movement-based interactions that so far has not been thought of as the usual material for designers. Here, ‘Experiential Bodily Knowing’ is realised through moving: “The exercise of walking backwards… helped me observe different behaviour on each person if their eyes are not in front of their faces and how different spatial assemblage it was versus when people walking forwards.”
Special mention was dedicated to the exercises that emphasised other senses in the body (beyond vision), which helps consider, not just how a design or a technology might look, but more importantly how we might ‘feel’ or ‘hear’ it:

“I have learnt that sound is a means to understanding space almost as powerful as vision, even if its understanding remains normally underestimated. There are some effects that are necessary to accomplish a certain degree of embodiment and interaction that cannot be achieved only by visual means. Sound has an enormous potential, it is a very vast field not easy to master and not directly understandable, but despite all these challenges it is worth trying to work with it.”

Finally, comments stressed the value they discovered from enacting a set of rules during the emergent behaviour exercise of the ‘body as interface’ workshop, which resembled the computational techniques the students are introduced to in the Masters programme, in particular, in the computational modules: “It was a magnificent representation of some of the ideas that we just started studying this semester, such as cellular automata that have simple rules, however produce amazingly complex structures.”

An important aspect, which emerged during the session, is related to how the students worked together to ‘perform’ an ‘improvised’ piece - what looked like a highly choreographed and rehearsed time-based performance piece - by following very simple local rules between two or more body points that generated a global outcome of dynamic moving bodies with complex spatial relationships between them (a kind of living architecture). This has provided a strong framework for ‘unintended’ collaboration. Here, working on the various body-space exercises individually and collaboratively became a game that they enjoyed and consequently this increased their level of collaboration (Figure 4).

CONCLUSION

Schön (1985) has outlined some of the dilemmas presented by the expanding horizon of knowledge within the architectural field. He identified a dilemma facing architectural schools as they start to identify the growing importance of new fields of knowledge to the education they must provide: “architecture may try to incorporate them in a way that imitates the technical education in other fields, thereby turning its back on the tradition of the architectural studio. Or, out of a wish to remain true to a certain view of that tradition – and to the image of the architect...architecture may turn its back on the rising demands for technical education” (Schön, 1985, p. 86).

The rise of pervasive media and networked technologies calls for an approach to designing the physical and digital environments as an integral whole and of a coming together of Architecture and Interaction Design. Key to this interdisciplinary integration is the body in space (with its social protocols, conventions and attached values).

In this paper, I presented an embodied perspective to view the contribution the synergy, between time-based performance media, architecture and interaction design, may provide towards an inclusive architectural pedagogy.

Incorporating computation and digital media into architectural teaching raises educational issues of how to infuse it into the process. In the AAC programme computational methods are critical component of the learning experience. The teaching in the ‘embodied and embedded technologies | Body as Interface’ studio presents an attempt to re-balance this through its emphasis on the body and body movement as a material for design,
and with the intention of helping students understand and gain awareness of important aspects and design principles within an evolving field of knowledge on the cutting edge of the research. Here, the focus is on how the human body relates to its subjective space, body movement and space perception and how this may affect the way it relates to its responsive surrounding and potentially to future adaptive and interactive environments.

I outlined a discussion about the significance of this approach as an architectural pedagogical tool and described the proposed methodology, which suggests a time-based design process promoting a body-based dialogue and exercises that enable students to observe, think and feel space and spatial interactions and in order to understand the critical relationship, create their own learning experience and generate rich and varied responses within time-based architecture. I argue that re-introducing the human body as the main focus will open up more possibilities to capture, understand and react to the human experience as it is mediated through digital technologies and promote the use of experiential learning as a key strand of creative exploration within the design studio.

The paper identified pedagogic issues that influence how students conceptualise the synthesis of body movement, technology and design work and raises a question of the extent to which research could and should ‘inform’ teaching. Crucially, it highlights factors such as participation, collaboration and understanding curiosity and the role of discovery as fundamental aspects in teaching and learning.

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REFERENCES


