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## How authentic does authentic learning have to be?

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### ABSTRACT

This study presents an analysis of self-reported student perceptions and experiences of authenticity during an undergraduate first-year problem-based learning (PBL) engineering module at UCL. The aim is to further understand how students perceive authentic learning experiences in order to support and maximise this kind of learning throughout their degree programmes. The data shows that our students did perceive their first-year experiences as authentic despite the fact that the context they worked in and the outputs that they created were not the most real-world part of their experience. The data supports previous work on authentic learning which suggests what really matters is cognitive realism and not physical realism. However, it may be possible to introduce levels of authenticity at increasing levels of complexity throughout the student journey. The analysis is located within the wider field of authentic learning, PBL and builds on this work to suggest how dimensions of authenticity may be graduated across a degree programme.

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## Introduction

Five years ago, UCL Engineering took the decision to revamp their existing undergraduate degree programmes and create more opportunities within the curricula for all students to apply their technical knowledge through practical application. This work focuses on the student response to a problem- or project-based learning (PBL) module (Kolmos, de Graaff, & Du, 2009; Du, de Graaff, & Kolmos, 2009), which is encountered annually by 650–750 undergraduate engineers across 7 disciplines within the Faculty of Engineering Science in the first term of their first year at UCL. The module, referred to as The Challenges, is the first of a series of authentic learning PBL experiences designed to support and encourage the development of skills and competencies alongside technical engineering knowledge. The Challenges are one of 9 PBL activities that run through years one and two of the undergraduate programmes. Together these make up the core activities of the Integrated Engineering Programme (IEP), which takes authentic learning as the touchstone of its pedagogy.

The aim is to further understandings of how students perceive the nature and the types of authentic experiences and to ask whether it is necessary or even possible to scaffold

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authentic learning. The analysis focuses on the ways in which students in the UCL programme report their learning experiences in *The Challenges*, using qualitative methods to tease apart dimensions of authenticity. These dimensions are based on those described by Strobel, Wang, and Dyehouse (2012) in their systematic review of the literature on engineering education, and they are used to code and map our student reports.

The term ‘authentic’ is used ubiquitously in the context of education and often without much definition. Some authors have made an attempt to specify elements and dimensions of authenticity in order to further the understanding of and to support the design of authentic environments (Barab, Squire, & Dueber, 2000; Herrington & Herrington, 2008; Petraglia, 1998; Strobel et al., 2012). This paper extends previous work to delineate and define authenticity, but our data are taken from the bottom up. Our initial question – how is authentic learning perceived and described by the authentic learner?

The long-term aim is to utilise improved knowledge of how our students perceive elements of authenticity in their programme, to create opportunities to offer them learning experiences which include effective, targeted and timely scaffolding. Knowing where students start from in their first authentic experience at UCL, may make it possible to create progressively more authentic and complex activities as they pass through their chosen degree programme. The principle pedagogies through which authentic learning manifests in the IEP are problem- or project-based learning approaches.

The two literatures, on authenticity and on PBL, appear to run on parallel tracks. Here the two strands of work are brought together in order to probe our data and suggest some ways in which elements of authentic learning could be used to structure PBL activities to provide our students with a potential trajectory of development through active, situated learning.

### **Authentic learning and PBL**

The concept of authentic learning is more of a philosophy, useful as a model for curriculum design rather than as a learning theory (Herrington, 2015). It grew out of a body of work that sought to understand learning in workplace apprenticeships. Brown, Collins, and Duguid (1989) described ‘situated cognition’ in an attempt to re-unite a ‘breach between learning and use ...’ or the ‘know what’ and ‘know how’ of a practice or profession (Brown et al., 1989, p. 32). Situated cognition is the idea that knowledge is almost always structured by context and progressively developed by use (Brown et al., 1989). To illustrate this, the authors cite studies on language acquisition, which show that learning language in the context of day-to-day communication is orders of magnitude more productive than learning lists of vocabulary divorced from use and context. In this reading, knowledge has something in common with a set of tools that can *only* be understood and retained through use. Knowledge, like tools and vocabulary lists, is not meaningful when it exists in abstraction from the context of real-world situations. Based on these ideas, Brown et al. (1989) called for changes to traditional teaching practice to make room for situated learning in authentic environments. Their work had implications across educational sectors and disciplinary boundaries and has led to a profusion of activities across all levels of education that place learning in an active, student-centred and more authentic environment.

Here the term authentic learning is used in its most general sense in which learning is supported by being situated in an environment that aligns learning objectives with real-world tasks, content and context. In this reading, authentic learning is based on a constructivist view in which students create their own understandings of new concepts and practices

by integrating their previous experience, the resources they have, their own research and their current experience. This is directly opposed to instruction based on behaviourist paradigms of learning that seek to simplify, pare down and abstract knowledge about an objective world so that it can be transmitted to the learner (Jonassen, 1991; Herrington & Oliver, 2000). A major paradigm transition from behaviourist to constructivist models of learning was a primary factor in stimulating a move to the design of real-world, complex, student-generated situated learning experiences. What followed was a growth in the application of authentic learning frameworks in higher education (Herrington, 2015), some of which were PBL elements. Although authentic learning and PBL are not always one and the same thing. Further to these developments in education, trends in engineering education that strove to promote the development of professional skills and competences in addition to providing technical instruction (Graham, 2012) gave the move towards authentic learning in this sector greater impetus. Such drives are in large part what led UCL Engineering to weave a common spine of authentic learning experiences through all of their undergraduate programmes. As a result of drivers from both education and engineering sectors, the practice of PBL has become well established as a successful, but very diverse practice in engineering education (Kolmos et al., 2009). Much as authentic learning is problematic when it comes to definition, so too is PBL, since there are many different forms of it. While there is much overlap between authentic learning and PBL, not all forms of PBL are authentic. PBL originated in the context of clinical education, as a way to structure medical knowledge through experiences that resembled those of professional practice (Barrows, 1986). Situated cognition, the structuring of knowledge in professional practice, self-directed learning, and increased motivation for learning are described as the principle learning objectives of PBL in the clinical setting in the 1980's. In broad terms these objectives are supported by both PBL and authentic learning frameworks (Herrington, 2015). Yet questions arise around the levels of authenticity and the extent to which constructivist learning paradigms govern curriculum design.

Savery and Duffy (1995) specify that PBL problems must include the concepts relevant to the subject domain and that the problems must be *real* because real life has richer, more multifaceted problems than are possible to fictionalise, real problems are more engaging and students may be more familiar with a real context than a fictional one. Barab et al. (2000) consider PBL as a special case of authentic learning, and support this argument for real problems by taking forward the notion of real life richness. They suggest that authenticity can neither be pre-planned, nor pre-authenticated by teaching staff. Rather in true constructivist fashion, the students must find their own authentic learning answers, in other words there *should* be many variations of right answer. Barab et al. (2000) go further, however, to argue that authenticity is an emergent property, which requires student 'buy-in' and this is a factor that cannot be guaranteed when teachers design problems, since what is real to the teacher may not be real to the student. To get around this difficulty, the authors propose that the audience *is* the teacher. In their view, the authentic task must be of value to students personally *and* of value to a real community of practice. In engineering terms this may mean working directly with industrial partners, public sector or third sector partners who require an engineering solution to a real problem.

To suggest that authenticity is more a perception than a state of the object is unquestionably a constructivist stance, which raises the question, usefully put by Petraglia (1998, p. 60) of how learners can be *persuaded* that they are experiencing (and learning in) authentic

environments? Taken to logical extreme, any preplanning in this context makes a mockery of learning outcomes. This is the challenge facing those of us who wish to create constructive, authentic learning environments for our students.

In answer to it, Herrington, Oliver, and Reeves (2003) suggest that what is necessary for learning and 'buy-in' is 'cognitive realism'. This concept was first raised in the 1980s (Smith, 1986) in an exploration of the process of simulation training, '[p]erhaps the important "reality" factor for those simulations designed to develop cognitive ability is less related to the form of the stimulus materials than to the form of the essential decision-making dynamic which underlies the simulation process' (Smith, 1986, p. 24). Herrington et al. (2003) go on to reproduce this conclusion in their study of authentic learning, within which they include examples of PBL, situated learning and anchored instruction. Like Smith (1986) they propose that a vital element of all successful authentic learning activities is realism in task design and they add student buy-in as essential as well. In their model the physical reality, which arguably includes Barab et al.'s (2000) audience *as* teacher, is unimportant. They conclude from analyses of materials and interviews with stakeholders, that the implications for practice of authentic learning (including PBL) is 'that less attention ... be paid to expensive high fidelity ... designs, and more to the design of the tasks that students complete ... [and] to the design of complex tasks and scenarios with multiple outcomes ...' (Herrington et al., 2003, p. 2120).

The level of congruence with real world activities is debatable. At UCL, The Challenges module has a measure of verisimilitude in the task, which has multiple 'correct' outcomes and no single right answer, but it does not go quite so far as Barab et al. (2000) propose. However, activities have been purposefully designed as complex, creative tasks which have no single correct answer.

This feature of The Challenges reaches into a scale of constructivist activity, which at one end simply presents students with information or an argument in some form and sets them some questions to answer around the set piece. This is what Savin-Baden (2000) has called 'problem solving learning', which she reported at the turn of the century was sometimes confused with PBL. Hanney and Savin-Baden (2013) describe a scale of PBL activities from narrow, single discipline problem-solving to more open-ended, inter-disciplinary, perhaps also ill-defined, problem-solving where knowledge may be contingent, contextual, creative and constructed by the learner. Within an engineering context, the kinds of problems that fit well at this end of the scale are design focused problems.

Given the variety of PBL activities that now exist, de Graaff and Kolmos (2003) set themselves the task of identifying some learning principles that are common to disparate models which include what was called PjBL (project-based learning) and PBL (problem-based learning). Hanney and Savin Baden (2013) too have differentiated between these two models and concluded that they are not necessarily the same in the UK at least. What they describe is a difference in the size or breadth of the potential learning space between the two models. PjBL is a goal-oriented process of making, testing or implementing. PBL on the other hand has a stronger constructivist perspective, in that it is more open-ended, creative, inquiry-based, complex and it encourages students to manage their own learning.

There is clearly overlap between these forms, which de Graaff and Kolmos (2003) explore with their unifying principles that span both PBL frameworks. They describe learning principles that are also shared by The Challenges at UCL. They are:

<b>The Challenges – Term 1</b>	
<b>Challenge 1 - Weeks 1-5</b>	<b>Challenge 2 - Weeks 6-10</b>
Single discipline Team-based Research-based project Self-directed learning Open-ended (research and ideate)	Inter-disciplinary Global Health Project Team-based Practical project Self-directed learning Specific and goal directed (model, build and test)
<b>Activity Flow Across The Challenges</b> The projects are based on an engineering design process, where Challenge 1 represents the early, ideational and research phases of design and Challenge 2 represents the later prototyping phases of design.	
NEED – BRIEF - CONCEIVE	SPECIFY-BUILD-TEST

**Figure 1.** Flow and nature of activities in the challenges.

- the cognitive domain describes cognitive learning that is organised around a problem and undertaken as part of a project.
- content is inter-disciplinary, includes theory and practice and models the relevant subject domain
- social describes the elements of PBL that are participant directed and team-based.

The difficulty here is that there is no sense in the learning principles of the extent to which these practices are genuinely in the constructivist vein, or whether they are closer to Savin-Baden's (2000) problem-solving learning, because that is equally possible to set up across disciplines and in teams.

To rectify this situation Kolmos et al. (2009) suggest a new model based partly on Savin-Baden (2000). What emerges are elements of PBL curriculum, such as problem type and assessment methods, that each sit on a scale between Discipline and Teacher-controlled approaches at one end, and Innovative and Learner-centred approaches at the other. These elements are expected to be aligned such that they all sit at roughly the same point on the scale between Teacher-controlled and Learner-centred. Specifically, Kolmos et al. (2009) warn against a curriculum that takes a 'zigzag line through all the elements' (Ibid., p. 15)

### **The challenges: IEP cornerstone PBL module**

The Challenges is a cornerstone PBL module of the IEP. It consists of two 5-week exercises (namely Challenge 1 and Challenge 2), which have the students working in teams on design-based problems from their first day of study through to the end of the first term. The content of the first Challenge is linked to disciplinary research areas and is partially aimed at inducting students to their new departments and their chosen disciplines. The second Challenge is an inter-disciplinary team-based design problem centred on the wider societal issue of global health.

Although The Challenges comprise two discrete projects, together they constitute a single learning journey, which moves from an open-ended creative PBL challenge into a narrower more goal-directed specified, build and test project (See Figure 1). The key activities of

Challenge 1 revolve around the exploration of user-needs, research and idea generation, whilst Challenge 2 is more constrained and technical. It is also inter-disciplinary. This second Challenge has more in common with what Hannev and Savin Baden (2013) describe as PjBL since it is goal directed and involves prototyping, modelling and testing of a specified solution. In terms of the overall cognitive task, the two projects mirror a single engineering design process (see Figure 1).

The first five-week Challenge fulfils two of the three PBL learning principles described by de Graaff and Kolmos (2003), because it is discipline specific, though it is a problem-oriented team-based exercise. The second five-week project meets all three learning principles, since it is also inter-disciplinary.

In all PBL elements bar single discipline, the first Challenge lies close to the Learner-centred end of the scale suggested by Zhou, Kolmos, Nielsen (2011). In Challenge 1, students are tasked with addressing a high-level design problem moving from user needs to design ideas, but no further. According to Zhou, Kolmos, Nielsen (2011) this would seem to constitute misalignment. The authors place importance on inter-disciplinary work because innovation is often the product of inter-disciplinary projects. This may be true, but the first five weeks of The Challenges takes in only the early steps of a design process and so students are expected to create design ideas in outline without detailed technical specification. At this level of ideation, the students still have a wide-open project and scope for innovation, despite the constraint of their disciplines. To put it another way, the learning space may be restricted by discipline, but within that space learners have an open-ended remit. In Challenge 2 students work within a more detailed scope in which they design a specified solution at the technical level. This exercise involves modelling or prototyping and testing some of the major components of a TB vaccination plant for a sub-Saharan African context. In this second situation, the learning space is much more focused, but is inter-disciplinary and if it were not, it would make no technical sense.

When it was initially implemented, The Challenges module was intended to give the first-year students an opportunity to put their learning into practice by working in an inter-disciplinary, problem-based, industry linked and design focused environment. It has evolved to include the discipline specific elements as well as the inter-disciplinary PBL activities and is now more closely linked to research across the Faculty of Engineering Science than with industry partners. Nevertheless, it remains a deliberate attempt to make use of and explore the creative and stimulating aspects of design and research as practiced by 'real' engineers and computer scientists.

PBL activities have long been documented as an effective means to enhance student motivation through the integration of 'real' problems (de Graaff & Kolmos, 2003). Such activities give each student the opportunity to put into practice their technical and theoretical knowledge, while at the same time developing a wide range of professional skills; skill sets which are increasingly emphasised by industry as key to graduate employability (International Engineering Alliance, 2013; Royal Academy of Engineering, 2007; Wakeham, 2016). These continue to be strong drivers for the development and optimisation of the IEP PBL activities and student learning experience.

## Methods

305 individual student responses to The Challenges module evaluation questions have been analysed. The student evaluation questionnaire (SEQ) was carried out online during or just after the final timetabled session of The Challenges. The responses comprise a data-set which represents 47% of the student cohort who successfully completed the module and the SEQs.

The SEQ included two questions aimed at providing data on which of the learning objectives students thought they had achieved on completing The Challenges. In this question, students checked a box against each of the Learning Objectives they felt they had achieved. Students were asked two further questions, which were open-ended and aimed at providing data for qualitative analysis through an inductive approach as exemplified by grounded theory (Glaser & Stauss, 2000).

The focus of analysis was on responses to the following three questions, which the students answered within the SEQ:

- (1) What did you like most about The Challenges?
- (2) If you could change one thing about Challenge 1/2, what would it be? (students were asked this question in relation to Challenge 1 and Challenge 2 separately)
- (3) Which of the student aims do you think you have attained on completing The Challenges?

Students were asked to type their responses to the open-ended questions into an online form. The aim of these two questions was to further our understanding of the student experience of The Challenges module. What emerged very quickly from a first review of the responses to the first question was a dominant theme around authenticity, which was followed through by mapping the responses to the dimensions of authenticity as developed by Strobel et al. (2012) following Barab et al. (2000).

With the aim of devising a model of authenticity for use at pre-university level, Strobel et al. (2012) analysed conceptualisations of authenticity in a systematic literature review taking in a wide variety of literature from the field of engineering education. Although, their drive was to inform curriculum design of pre-university education, most of the literature they reviewed related to undergraduate levels. The analysis utilises a coding system that is based on the same dimensions of authenticity:

- *Context Authenticity*: Content is or resembles real world content (e.g.: the data or the problem or both are real).
- *Task Authenticity*: The process/activities resemble real world activities (e.g.: design, research, teamwork, reports etc.).
- *Impact Authenticity*: Student outputs are used outside the education environment (e.g.: community or industry based projects).
- *Personal/Value Authenticity*: Strobel et al. propose two additional dimensions of authenticity, one (personal authenticity) in which projects are close to personal life, and another (value authenticity) in which students' own questions get answered or the project itself satisfy personal needs.

Here, discussion and analysis focuses first on what the students tell us in general about 'buy-in'. What do these students believe and what do they not? Then the results of mapping student responses to Strobel et al's (2012) four dimensions of authenticity are explored. Out

of a total of 305 responses, 249 were coded according to the categories above. Responses that were aligned with more than one of the authentic dimensions were coded twice.

## Analysis

### *'Buy-in' and cognitive realism*

It was clear from an initial reading of the responses to question a) that authenticity of various orders and kinds is the strongest single theme among the things students liked. In all, 74% of students who completed the survey, described a dimension of authenticity as the feature of the module that they had liked most. This is powerful endorsement for authentic learning approaches and it supports the observation that students maintain high levels of engagement and motivation in authentic PBL activities (de Graaff & Kolmos, 2003).

There are references to situated knowledge in some of the student comments. Most students gave short answers that referred to a 'realistic working context' and 'what engineers do in their day-to-day working life', but a few gave lengthier answers that gave a stronger impression of 'situated cognition' (Brown et al., 1989). For example, one student wrote,

I like the simulation as an engineer, tackling real-world challenges. The experience provides an insight on the daily work of an engineer and trains us to handle the workload and stress expected of an engineer. We have the opportunity to design models and apply engineering software to facilitate some of our work ...

This student clearly values the placing of his/her learning in a situation that mirrors professional engineering. Another student took up the student-professional theme more directly,

This kind of exposure at an early stage of the degree helps students to understand what and why they are learning the modules in the years to come and also have a clear career path from the very beginning of the degree. I believe it does help narrow the transitional gap between university life and actual working environment.

A further comment refers to the mix of skills that sit around the technical knowledge required in 'real engineering',

It [The Challenges module] gives students a realistic expectation of being an engineer and the things that come with it i.e. planning, research and presentation and not only thinking that engineers do lab work only.

In general, these comments indicate that these students have bought-in to the authenticity of the PBL experience. This is a pleasing result because the curriculum was designed in the most part to mirror professional engineering practice. So that students are working through technical projects at the same time as they are handling teamwork, planning and independent research.

The student buy-in that is evident here, supports the notion that there is a level of 'cognitive realism' (Herrington et al., 2003) within The Challenges curriculum. Furthermore, some of the student assignments constitute uncommon outputs for professional engineering contexts, such as a video assignment in Challenge 1. A small but significant number of students raised the video as the one thing they wanted to change in Challenge 1. Of 236 replies to question b), 39 students, nearly 17% of those who replied to this question, said that they wanted to remove or change the video. Most of these responses related to ideas about the video as wasted or misdirected time. For example, one student said 'the video requirement resembled a media studies class instead of a computer science course', while another

asked for ‘a little more time to work on the design for the engine and to not make videos to present the design’. A third remarked that a ‘... [p]resentation would have been more useful’. Students did not ask for changes to other assignments in response to this question. The other assignments that these students undertake are more common professional-style outputs, such as a team reports and presentations.

The difference between the videos and the other assignments is possibly that the video assignment is not perceived as an authentic output for a ‘real’ engineer. This goes some way to answering Petraglia’s (1998) question about how to persuade learners that they are in an authentic environment. Our data suggest that mirroring real-world engineering (or other professional) outputs is an important feature in doing this. Or rather that including outputs that are unusual in the relevant professional world may reduce levels of buy-in, despite the fact that they provide opportunities for creativity and design in themselves.

Despite losing some student buy-in over this particular assignment, there is very clear overall support for the authenticity of The Challenges. Yet, there are features of The Challenges, aside from this assignment, which do not meet the standards for authenticity in the way that some authors call for. The problems are real, but the students do not provide outputs for a professional audience in The Challenges. Where Savery and Duffy (1995) were content with a real problem, Barab et al. (2000) stipulated that the student outputs must be of value to the student *and* to a relevant community of practice.

The majority of student outputs are modelled on real-world engineering outputs, but they are not of use to a *real* community of practice. They simply mirror it. For example, Challenge 2 mirrors the real project to build capacity in sub-Saharan Africa to manufacture vaccines. Students do some detailed technical design, prototyping and testing of components of a vaccination plant, but they do not present these to prospective vaccine manufacturers because the projects are not *yet* advanced enough to be of value to a *real* community of vaccine manufacturers. When they reach their third or fourth year this may have changed, but the fact that the first year students buy-in to the authenticity of The Challenges anyway suggests that what they are responding to is indeed the cognitive realism stipulated by Herrington et al. (2003) following Smith (1986). Just mirroring professional processes and outputs appears to be authentic enough for these students, without the need to provide a fully professional context or a *real* client.

### **Dimensions of authenticity**

On a closer analysis of the data from question a) several categories of authenticity emerged, which led to the question of whether these students perceived the same dimensions of authenticity that Strobel et al. (2012) described would bring students closer to the professional environment. The data from question a) corresponded to some of the dimensions of authenticity that Strobel et al. (2012) find in the literature.

Students’ responses were categorised using the definitions of dimensions of authenticity described above. On reading Strobel et al. (2012) the authentic dimension that relates to ‘context’ is relatively unbounded and includes the setting of the problem (as in the setting of a *real* problem), but it also includes dimensions of the working environment. It is not easy to draw a line between the work-environment and elements of the task. Teamwork, for example, is arguably task related and the work-environment. In the coding, Context Authenticity is defined *only* as problem authenticity, because the line between task and

**Table 1.** Frequency of authenticity dimensions.

Authenticity domain	Number replies related to domain	%
Task (Practical)	56	20
Task (Professional skills)	168	61
Context	28	10
Other	13	5
Disliked the module	9	3
Total of codes	274	

work environment is unclear in this regard. This is possibly why the dimension of Context Authenticity in our sample only emerges in 10% of responses referring to authenticity. Those students who talked of enjoying the context, referred to the stated purpose of, ‘The project itself ... about the making of tuberculosis [vaccine] ...’ and ‘the chance of working on an actual project with society implications, would be the things I liked most about [The] Challenges.’

The overall trend in our data-set favours Task-related Authenticity by a long way. In total 81% of the responses that included comments about authenticity referred to qualities that were related to the task. This is perhaps because Task-related Authenticity is the most obvious dimension. However, the task-related responses are presented in two clear themes. One set of students liked the actual hands-on ‘practical’, making and doing, whilst another set valued the task-related ‘professional skills’ such as teamwork, communication and problem-solving.

Students who valued ‘doing’ quoted such activities as the ‘hands-on practical work with the microcontroller system’ and ‘building models for the dam and water flow experiment.’ In this subset some students indicated that they enjoyed the practical application of the theory they had learned, for example, one student talked of the ‘analytical and calculating side of the Challenges’ and another ‘building the dam model and testing the reservoir efficiency’. This set of responses is entitled ‘task’ (practical) and it was applied to responses which flagged making, doing, and applying theory.

Table 1 gives the frequencies with which the dimensions of authenticity occurred in student responses to question a).

Of the Task (Professional Skills), team-working was the most frequent to emerge and working with people from other disciplines was another highly favoured task process. Some students reflected on relatively complex skills that they felt they had learned from the task of working in a team, such as self-awareness and cooperation. One student said that s/he:

... liked the fact that I was able to interact and collaborate with people; this improved my social skills, and it has made me a more co-operative person. Also, it has gotten me into the habit of asking questions when I do not understand something.

Another felt that teamwork:

... helped me understand my strengths and weaknesses working in a group setting. Moreover, I learnt how to communicate better in a group made up of people from different international backgrounds.

These examples raise some impressive skill sets that students feel they develop as a result of the team-based task. One of the logical developments from personal development like this is the shift from working in teams to working as a team leader:

**Table 2.** Frequency breakdown of task (Professional skills).

Professional skills	Number replies coded	% of Total replies	% OF PROF. SKILLS
Teamwork	86	<b>31</b>	51
Inter-disciplinary Work	55	<b>20</b>	33
Other Professional Skills	27	<b>10</b>	16
Total Prof. Skill Codes	168		

Challenge 2 allowed me to explore the role of team leader ... This has helped my self-esteem ... I was able to experience the complexities that came with making decisions, as many of them were philosophical and opinionated in nature ... It also taught me the meaning of leadership in that it was not a managerial role but rather one whereby an individual seeks to help those around them grow, as I have felt the urge to let each of my team members experience, to the best of my ability and as much as they can, a task that they were both equipped to handle yet similarly unfamiliar with, such as the research of programming languages ... Overall, this has given me a niche experience and has changed my perspectives of leadership, revealing the true complexities that come behind their apparently simple decision-making ...

This student has reflected a relatively nuanced understanding of what leadership means for a first year undergraduate. The description of what s/he has learned is an excellent example of the kinds of development that PBL and authentic learning can offer to students through teamwork and open-ended problem-solving. The raised awareness of self, others, grey areas and/or complexity in decision-making that these students say they learn is, in management terms, a step on the pathway toward leadership (see for example, Higgs & Rowland, 2010), which is one of the learning objectives for The Challenges module (see Table 3).

In addition, the learning that these students have attained here is emergent and constructed between the student and the learning environment. There were no prompts, scaffolds or talks on self-awareness, cooperation or fuzzy decision-making. There was only the social dimension of PBL (de Graaff & Kolmos, 2003; Kolmos et al., 2009).

Inter-disciplinary work was not separated from teamwork in the analysis shown in Table 1, but there were a significant proportion of students whose responses were coded as Task (Professional Skills) who referred in particular to the inter-disciplinary connections. Table 2 shows the breakdown of professional skills between teamwork and inter-disciplinary work. Students who enjoyed inter-disciplinary work referred to enjoying 'the integration between the other engineering departments and how each project was interconnected for one big goal'. Another referred to 'the diversity it provides in order to work with different departments, on a fairly large project'. Learning in this area seems to have been satisfying because it brings together different or diverse knowledge.

Table 2 shows the way the Task (Professional Skills) dimension of authenticity breaks down. Teamwork was the most commonly favoured element of The Challenges by all students. It is also the most frequent of the professional skills, which students say they enjoy practising.

When students were asked which of the learning objectives they felt they had achieved they also chose teamwork more frequently than other skills. Learning objectives were explained and published to the students at the beginning of the module and were the same for both five-week PBL elements. Table 3 shows the spread of perceived achievements related to the learning objectives.

**Table 3.** Bar chart: frequency of learning objectives.



The range of our learning objectives (LO) for The Challenges is in fact predominantly task focused. Only LO c) on human centred design and perhaps also LO d) on design requirements and constraints are related at all to the external real-world context for which the students are creating designs. All of the other LO's relate to authenticity dimensions of Task (Practical) or Task (Professional Skills) and even c) and d) have strong elements of task to them. In general, it seems that the spread of student perceptions of authenticity in The Challenges matches the spread that are in the LOs.

Two of Strobel et al.'s (2012) authenticity dimensions were not recordable in our data (Personal/Value Authenticity and Impact Authenticity). Strobel et al. (2012) suggest including an extra dimension which they feel is neglected in the literature and should be Personal/Value. In this case, students were asked what they *liked* most about The Challenges and so the question is likely to call forth responses that automatically sit within the Personal/Value domain for our students at least at the meta level. That said, in Strobel et al. (2012) describe the Personal/Value dimension of authenticity as relating to material that might be close to student personal lives in physical terms, or to the personal questions that they have. What these results suggest is that in fact an authentic learning experience such as this at a Higher Education (HE) level may connect to the personal values of students because of the nature of the learning. Many of those students who said that they learned complex social skills from their interaction in teams appeared to be describing experiences that were answering personal questions. The fact that PBL includes the social dimension of learning appears

to be a strong motivating factor apparent from the student responses to what they liked most. The result also aligns with the idea that PBL is in itself a motivational experience (de Graaff & Kolmos, 2003).

Finally, Impact Authenticity is a dimension that Strobel et al. (2012) find relatively commonly described in the literature, which is absent from our data-set. This is presumably because none of the student outputs from The Challenges are used outside the undergraduate context and so they do not meet the definition of Impact (Strobel et al., 2012). As discussed above, it is interesting to note on this account that our students still found the experience authentic despite the fact that their outputs were not used in a real professional setting.

## Conclusions

The literature on authentic learning describes a partial shift in HE away from behaviourist pedagogies to more constructivist models of learning (Herrington & Oliver, 2000; Jonassen, 1991), which lend themselves to curriculum design that situates learning in problem-solving and projects that mirror professional practice. UCL Engineering has undergone a similar shift and its Integrated Engineering Programme (IEP) has provided authentic problem- and project-based learning (PBL) activities across all of its undergraduate engineering programmes for the last four years. Data arising from the first term, first year PBL activity, The Challenges show that these students tend to call forth a dimension of authenticity when asked about what they like most about the PBL module. In line with what Herrington et al. (2003) describe as ‘cognitive realism’, the activity consists of project-based tasks that take students through the steps of the real-world thinking processes of engineering design. This appears to be the main feature of The Challenges that these students buy-in to.

Both the cognitive process that the students undertake and the content of the module are authentic and map to two of the four dimensions of authenticity described by Strobel et al. (2012) in their systematic review. These are ‘Context’ and ‘Task’. The data presented here suggest that if these dimensions are present in the curriculum, together they provide enough cognitive realism to ensure student buy-in. This is further supported by the fact that the single most popular change requested by these students was removal or format change in the only assignment that presumably does not mirror real-world engineering practice in The Challenges. They requested a change to a video assignment, which demonstrates the need to mirror professional outputs to maintain student buy-in, even where students are not presenting or utilising outputs for a professional community.

Indeed, The Challenges provide none of the Impact Authenticity that Strobel et al. (2012) describe in their systematic review and that Barab et al. (2000) sees as an essential component of authentic learning. This example in engineering education confirms the proposal that the cognitive process is what really matters to student buy-in to authentic learning (Herrington et al., 2003). In many ways, this finding answers the question of the title – authentic learning needs to have cognitive realism. This is a useful result in that it provides a base-line from which to start authentic learning in year one of undergraduate study. It also provides an opportunity to design graduated activities that are increasingly complex and more authentic, in a scheme such as the following:

**Year 1:** Problem- and Task-based authenticity are sufficient to provide cognitive realism (e.g.: The Challenges)

**Year 2:** Introduction of more Context/Impact Authenticity (scenario experiences in which students begin to discuss ideas and designs with external partners or clients, but still do not have to create professionally operational outputs)

**Years 3/4:** Introduction of full Impact Authenticity (industry-led inter-disciplinary projects in which students create useful professional outputs for a client)

Finally, the data from this first-year cohort of engineering undergraduates suggest that Task-based Authenticity (Strobel et al. 2012) is perceived as two distinct types of activity. These students differentiate ‘practical’ task-based activities, such as building, testing and analysing from ‘professional skills’ related to the task, such as teamwork and leadership. This particular level of granularity offers a checklist in curriculum redesign that is driven by calls from industry to produce graduates who have extensive professional skill sets (International Engineering Alliance, 2013; Royal Academy of Engineering, 2007; Wakeham, 2016), since it allows students to develop situated technical knowledge, professional skills and to repair the breach between doing and knowing.

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No potential conflict of interest was reported by the authors.

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