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# Sketch-a-park

## Study of the usability of diagrams for participatory sketching

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## ABSTRACT

Children's view in participation currently gaining popularity (CABE Space and CABE Education, 2004) along with digital tools of participation based on design exploration currently known as Digital Participatory Platforms (DPPs) (Falco and Kleinhans, 2018), (Gün et al., 2020). Space Syntax Theory (SST) offers a well-proven human-centred analytic framework with applications for public engagement via digital twins (Dembski et al., 2019). Yet, as some authors argue (Baeck and Saunders, 2015), (Dembski et al., 2020), more needs to be done to improve the experiential side of these systems and empower citizens and children, in particular, to carry out their designs within these events using what is. We argue that using diagrammatic sketching as the basis of DPPs is particularly suited for SST since most SS models work out abstractions of urban morphology which can be drawn using simple diagrammatic sketches. However, this type of drawing may prove too abstract for participants and questions remain open regarding the usability of this type of drawings in a participatory environment. It is yet to be proven whether general members of the public, in particular young kids, can engage with diagrammatic sketches and what influence digital environments have on this engagement.

To address these questions, we carried out two pilot studies with participants aged 10 to 11-year-old where we asked them to carry out drawings of urban proposals with different levels of information regarding diagrammatic drawings. Tests were repeated with different groups making paper drawings as well as using a bespoke digital tool at different stages of the drawing. We develop an analytic framework for drawings and carry out a comparative study of the material produced. Results from the experiment suggest that 10- to 11-year-old can easily understand the abstraction behind diagrammatic sketches and adopt this technique as a form of expression. We observe that this happens more markedly when using digital tools. This suggests diagrammatic sketches have the potential to be deployed as part of a SS driven participatory tool.

KEYWORDS,

Digital sketching, Diagrams, User Experience, Participation

## 1 INTRODUCTION

The introduction of children's views in planning practices (CABE Space and CABE Education, 2004) is becoming a factor that authorities are taking into more careful consideration (Frank, 2006) since they are likely to be one of the main beneficiaries of properly designed public spaces. Authors such as (Clark, 2007), emphasize how collaborative work between designers and children helps architects open a "window" into children´s mind that help the design gain perspectives beyond common themes (ie bright colours, spatial organization, etc). Furthermore, authors such as (Birch et al., 2017) focus, not so much on the treatment of children as clients or receivers of a product, but as actual "partners" in the spatial design process, whereby the role of the children is that of bringing a disruptive capacity to the creative process. For this purpose, the authors use the term "third mind" as this newly generated creative space between professional designers and children.

Space Syntax Theory is beginning to make inroads into participation and engagement, although not specifically targeted at children. (Dembski et al., 2019) and (Dembski et al., 2020) include SS analytics as part of a Digital Twin deployment for public engagement in combination with environmental indicators. The authors indicate how the intuitive nature of SS analysis and its good correlation with other variables were well perceived and understood by the public. Yet they also note the need to add other forms of data besides the environmental evidence, linked to socioeconomic and experiential realms. This resonates with the views of (Senbel and Church, 2011) who talk about the need to generate tools that move participation towards more meaningful forms of co-production. The authors build on the idea of empowerment from (Bush and Folger, 2007) as a form of defining their position on a design-based approach to participatory design along the lines of what is typically called sketch planning (Hopkins et al., 2004) and (Goodspeed, 2016).

Tools and methods that would allow participants to engage in design while obtaining SS analysis fall within the category that (Falco and Kleinhans, 2018) (Gün et al., 2020) call Digital Participatory Platforms (DPPs), which has recently emerged as a field of research regarding its applications and positioning in participatory planning. These tools work as 3D online environments such as qua-kit (Mueller et al., 2020), CityPlanner (Bentley, 2020) and (ESRI-ArcGIS Urban, 2020), image collages (unli-diy.org, 2021) or maps (Zhang et al., 2019) and (Jankowski et al., 2016) that can provide live feedback on the design being carried out. Similar work has been done with children and young participants, typically as part of a gamified environment working on a pixelated landscape based on Minecraft (Block by Block, 2020) or similar interfaces (Polychronaki et al., 2018). However, online participatory tools that use the

type of drawings that would constitute SS analysis, such as diagrams of road centre lines or axial lines have not received enough attention either in adult or young participation.

While their low level of detail turns these diagrams into a flexible tool, easy to draw and modify, they may prove too abstract for children, as well as general members of the public to adopt or understand. Questions on the usability of this type of drawing remain open if they are to be adopted as forms of public participation. Our work addresses these issues and describes an experiment developed to understand the extent to which children use diagrams as a form of expression when thinking about the city in general and urban design in particular. The main research question that his chapter tries to answer is the following: *Are diagrams a form of expression that is understandable by participants and that can be deployed in a survey environment?* This question is broken down into simpler questions that help us structure our research methodology.

Research Question 1: What are the types of drawings that participants typically carry out when asked to develop an urban proposal? The underlying hypothesis is that participants are likely to produce object-based drawings or building sections when asked to draw on a white piece of paper. If the exercise is carried out on a site plan with context references, they are likely to borrow general map conventions and represent their proposals in sketch-map form. To evaluate this hypothesis, we set up a first pilot study with 10 to 11-year-old young participants where we ask them to make paper drawings of an urban proposal. Participants are asked to carry out these drawings on a white piece of paper as well as a blank site showing the surrounding context. We develop a categorisation of drawings ranging from concrete ones (objects, sections) to more abstract ones (diagrams). We then use this categorisation to analyse all drawings and compare the results produced with the two different bases (blank and including the site).

Research Question 2: Do participants use diagrammatic sketches to develop landscape proposals when briefed about this technique? We assume that, when we explain what diagrams are and how to draw them, some of the participants will adopt this form of expression. Other drawings will become more abstract even if they cannot be considered diagrams. If the proportion of people using diagrams is high (>50%) by the end of the exercise, this would be an indicator that diagram development is an exercise that can be replicated later in other participatory environments. To answer the research question, two weeks after the previous exercise we give the same group of students a series of exercises (1-2 hours) to train them on how to draw clean, line diagrams of connective paths. We then ask them to draw another proposal for the same site. We evaluate this second set of drawings using the same categorisation used in the previous section comparing the results. This indicated the impact of training on the overall process.

Research Question 3: What is the influence of online sketching tools on the type of drawings carried out by participants? This question assumes that the medium utilised to make a drawing is

likely to influence the result. In the case of a digital canvas, we hypothesize that participants will increase the level of abstraction of their drawings when measured in the scale previously introduced. Drawings made in paper alongside a digital tool will "borrow" from the digital realm and become more abstract than those drawn independently. To answer this research question a digital drawing tool is developed where users can make line diagrams on top of a blank site with context indications. We carry out a second pilot study with young participants asking them to make paper and digital drawings of an urban proposal. Both paper and digital exercises use the same context image as a base. Several sessions are organised so that the tool can be introduced at different moments in the exercise. In some events, the tool is provided alongside the paper exercise and on other occasions, this is used at the end of it. We compare the results of drawings obtained in the various events to see what the influence of digital input on the results is.

Research Question 4: What is the influence of the feedback generated by online sketching tools on the type of drawings carried out by participants? We assume that if the digital tool gives live feedback on drawing quality users will make more drawing attempts and try to improve their final drawing. In the case of children, framing the feedback playfully should increase both engagement and quality. To answer this question, the digital tool includes a feedback mechanism that analyses the shape of the drawing and tries to predict the resulting landscape style according to four pre-defined categories. In the first version of the tool, the feedback on the predicted style is given at the end of the exercise so that participants can then change the design if they feel the outcoming style is not what they had in mind. In a second version, feedback is given through a guessing game where participants are asked to amend their drawings until their guess is "right". We collect data from both options and compare drawing quality and the number of attempts.

In the following section, we develop a method to analyse and categorise drawings according to their spatial and diagrammatic character. We do this after reviewing the literature on children drawing as well as sketch map analysis to end up with a method tailored to our experiment. This is then followed by sections outlining the two pilot studies followed by conclusions.

## 2 LITERATURE REVIEW

A substantial body of work has been developed beginning with attempts to understand how children use their environment using drawing. In their seminal work (Lynch (Ed), 1977) carries out studies on how children map their environment in various cities using the method already outlined in the sketch maps explained by (Lynch, 1960). The authors find clear common traits that are further developed as guidelines to carry out surveys using sketch maps, which have been widely accepted for children's participatory methods.

(Halseth and Doddridge, 2000) set KIDSMAPPING as a wide outreach project to collect sketch maps from over 1,000 students and analyse how variables such as distance from the area drawn would influence the quality and detail of drawings. They also compare drawing quality across

groups and observe how common traits appear across pupils of the same class and emphasize the influence of the briefing and class environment on the outcome. More recently (Agarwal et al., 2021) carry out an extensive review of drawing analytics and conclude how sketch maps help children emphasize physical, perceptual, cognitive, emotional, and social parameters for developing a child-friendly environment in parks and open spaces.
(Harwood & Usher, 1999) score maps drawn by children asked to draw their route from home to school using descriptors such as spatial arrangement, scale and proportion, perspective, symbolisation and content.

Other authors use kids' sketch maps as collaborative mapping methods, trying to identify real-map features from participants' work. (Wridt, 2010) allow children to hand sketch over maps (using transparent acetate) to later gather a collective GIS of overall information about their perception of the city. Using more open sketch maps (Freeman & Vass, 2010) involve children in consultation processes to then assess the quality of the material produced and correlate it with interviews. The authors find that factors such as expressiveness and accuracy were heavily influenced by the cultural and educational context of students.

The previous works proceed through an assessment of the content of the map from a perspective of the items and connections suggested in them. More recently (Canakcioglu, 2015) works more specifically with the geometry and topologies of the maps processing them via SS analysis. The author extends Lynch's imaginative space parameters using (Piaget and Inhelder, 1967) description of the children's spatial awareness, namely topological (proximity, separation, order, enclosure and seriation), projective (straight lines, parallel lines and perspective), metric (Euclidian) and space parameters (conservation, block expression). The author then adopts SS tools to analyze drawings of their home and neighbourhood and correlates with research (Çanakçıoğlu, 2013) on how income and social class influence indirectly the nature of the spaces they live in (gated communities, shared spaces etc).

Yet the work from these authors is based on sketch maps as forms of expression. These drawings can be considered a concrete version of what is called a "cognitive map, which was coined in the 50s by (Tolman, 1948) when referring to the mental construction that humans fabricate for themselves to navigate their day to day spaces. Sketch maps, as a translation of these cognitive maps into drawings, may include paths, nodes, edges, districts or landmarks, paths, links and nodes (Tversky, 2003) and typically would be based on conventions borrowed from map representations of the urban environment, ie. roads drawn as double lines, roundabouts as two concentric circles or similar. These drawings, while may contain topological information that relates positively to SS analysis, (Kim and Penn, 2004), (Zheng and Weimin, 2010), (Haq and Girotto, 2003), will require extensive work of processing before the introduction to SS analysis including scanning, manual extraction of axial lines and later identification within a larger map, hence hindering the live result required for DPP deployment. Existing sketch map processing

may help to bridge that deployment gap (Spatial Intelligence Lab, University of Münster, 2020), (Zardiny and Hakimpour, 2020), (Zardiny et al., 2020) translating sketch maps to real maps, however, final live deployment has not been carried out and further testing would be required to form part of a DPPs package. Furthermore, sketch maps typically include more detail than necessary for the design process, while simple line diagrams are typically the nature of drawings used by practitioners for design development. We need to look further into this last type of diagrammatic drawings or simple sketches such as road centre lines.

While diagrams were widely theorised during the beginning of the 2000s as a form of architecture ideation and formal inspiration (Garcia, 2010), they have not had enough attention as part of children's drawing theory. This type of drawing would relate more to what (Winnicott, 1989) calls "squiggle" to the free drawing which he used as a form of initiating conversations within the therapeutic process within the so-called "squiggle game". In these games, children are asked to interpret an abstract scribble given to them and "complete" them into a finished drawing. The author refers to a "third area" generated thanks to the capacity of the abstract drawing to suggest, where ideas of children and adults can overlap and create a common point of understanding. Diagrams as (Allen, 1998) would suggest, are projective tools, mutable and open to interpretation. They, therefore, share the abstract and creative characteristics of squiggles while maintaining the spatial character of sketch maps. However, there is little research as to how children may engage with them when discussing space. We therefore will consider a drawign category which incorporates this type of drawings within our drawing analysis.

Based on the existing literature on the analysis of spatial drawings of children, we propose a bespoke category that addresses the objectives of our research, namely, measuring the extent to which the spatial drawing incorporates abstract design features such as the ones produced in diagrammatic sketches. This is broadly organised in a growing level of abstraction, beginning from object-based drawings to pure diagrammatic sketches of space. The following points give an accurate description of this categorisation:

- OBJECT: These are drawing composed of individual items (animals, people, cars, buildings) floating in space without the main system in the background that connects them or serves as a way of organizing them.
- SECTION: These drawings would be formed by the elevation of buildings or street which contains or organizes any objects or elements in the drawing. This can be a representation of a street frontage or building section with different uses, people or objects working at different storeys. In these sections, ground, walls and roofs help relate the different items or objects so that basic ideas of adjacency can be described (besides, below, above etc).
- SKETCH MAP – PLAN: The drawings depict a part of the urban / landscape fabric in a plan. Elements are organized by a network of paths or roads that connects or gives shape

to the overall system. This type of drawing would borrow from conventions used in map development such as double lines representing paths or two concentric circles for roundabouts. This category would correspond mainly to what was previously discussed as a “sketch map”. In many cases, plan and section may be combined, with buildings or items shown in section.

- SKETCH MAP - SUBDIVISION: These drawings depict a part of the urban / landscape fabric in a plan. Different elements appear organized by the partition of space where the participant arranges plots adding them side by side or dividing them sequentially. Subdivision, rather than the connection of components, drives the drawing, mainly represented with single lines. This makes the drawing slightly more abstract than the plan map since the connection system is less explicitly assimilated into conventional sets of double lines found in maps.
- SPATIAL DIAGRAM: These would be a more abstract version of a map. While the nature of the drawing itself would be more akin to that of a squiggle, it is nevertheless related to the context offered in the plan. Paths and roads would typically be represented as single lines. In this type of drawing, there is little or no reference to objects depicting features.
- OTHER: This relates to drawings or squiggles unrelated to the exercise.


Figure 1 Drawing categorisation

# 3 PILOT STUDY 1: DEVELOPMENT OF DIAGRAMS USING PAPER-BASED DRAWINGS

This first pilot study addresses research questions 1 and 2, regarding the natural tendency of participants when asked to develop sketches as well as their capacity to understand the nature of diagrams. It is carried out with paper-based drawings in two schools in Dundrum (South Dublin) with a series of 10 to 11-year-old students where we ask participants to develop different types of drawings concerning the regeneration of Dundrum parking and shopping mall. The total number of children engaged was around 100 This is framed as a collaboration between the Irish Architecture Foundation (IAF) and the "Imagine Dundrum" association with input from the research team as the organiser of an interactive design workshop with two local schools. The ideas collected from the workshop were shared with Dublin City Council (DCC) afterwards.

## 3.1 Precautions undertook when working with children

Several precautions were undertaken when working with children to ensure an ethical procedure and protection for participants. The research team communicated the intentions and schedule of activities with the school representatives. During all stages of the experiments, a member of the school staff was present and supervised all activities. Permission to use drawings was obtained from the schools. It has to be noted that all data gathered were anonymous. In all cases, no data on name, ethnicity, religious background or gender is collected. No images of the kids were taken. Finally, clearance for work with young individuals was obtained from the Irish police due to the lack of criminal records of any of the experiment team members.

## 3.2 Experiment structure and sequence

The entire exercise was broken down into a series of stages with different levels of training on how to draw diagrams. This allowed the researchers to understand the impact of this training and the ultimate adoption of diagrams within the participatory process.

STAGE 1: FREE SKETCHING: The first phase of the experiment takes place before the team arrives at the school (see base drawing 1 in figure 2). Students are given the task "Before you go on the walking tour, please draw your future Dundrum" "Use your imagination, please draw what you would like to see built on the site of the old Dundrum Shopping Centre. Anything is possible!". This was accompanied by a white canvas with no indication of the type of drawing or technique. A section below includes an area to "Write about your Dundrum" with sections for "Past" and "Future". Another page is given showing the site plan with the context of Dundrum. The schools had the freedom to carry out this exercise during class or as part of children's home activities.

The students are then taken on a walk around the site with historian John Lennon to raise awareness of the past of Dundrum and help them look at the city's history. They are given the task to "Draw your future Dundrum" using a small-scale plan of the site (base drawings 2 and 3 in figure 2). Participants can make annotations or writings of their land-use preferences on the drawings as these are developed. We also wanted to ascertain the extent to which the context drawing provided influences the final production (ie it prompts users to think in plan).


Figure 2 Base drawings delivered for Stage 1 participation before site visit (1 and 2), after site visit (3) and after diagram introduction exercise (4 and 5)

STAGE 2: ABSTRACT DIAGRAMMING EXERCISE: This second stage takes place two weeks after the first drawing exercise. It begins with an introductory exercise on the development of diagrams as a form of expression composed of a series of short talks, exercises and games with a total duration of 2 hours. These are meant to allow students to understand the nature and use of diagrammatic sketches and point to the relationship between these diagrams and the landscape character.

The first exercise (Abstract Diagram Exercise on the left of figure 3) has the objective of forcing participants to think about lines as paths and is based on groups of four participants each. Each group gets four pages, each of them divided into four quadrants. Participants are asked to think of ants moving through the park and draw a path that they would leave in one of the quadrants. After each team member draws a quadrant the drawing is passed on to a colleague. Their companions complete their quadrant matching the endpoints of the "ant" that drew the previous quadrant. Participants are asked to carry out a similar exercise, this time trying to match the style inherited from the first group member. The participants are shown four photographs of landscape design that clearly show strong geometrical style (curvy, rectangular, circular shapes or triangles/facets) and are asked to find areas in the squiggles previously made that match any of the characters shown to them.

In a second session (Ant exercise on the right of figure 3) participants are asked to make a collaborative "diagram" or "squiggle" using their steps as they move through a carpet painted with thermochromatic paint. The idea is that, as they move and step on the paint with their bare feet, the paint heats slightly and its colour changes temporarily. Using an analogy of the ant colony leaving traces and forming lines, participants are asked to "draw" lines with their

movement, preferably trying to match one of the ant drawings previously carried out in the group. The character of the remaining lines or traces is then discussed in the group.

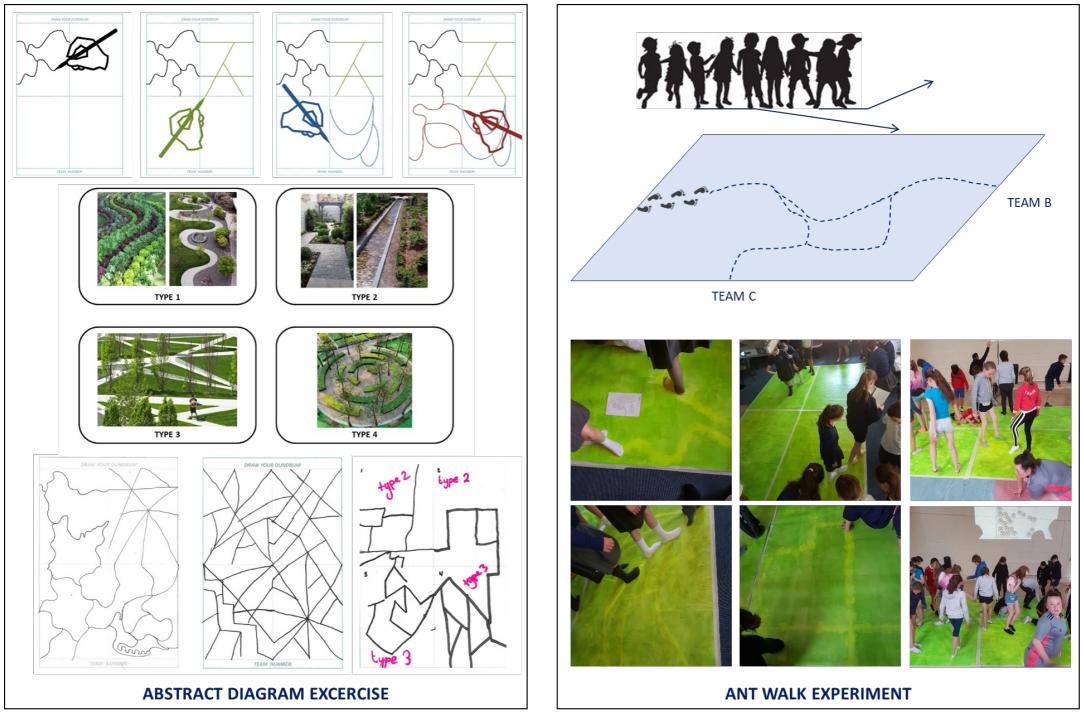


Figure 3 Diagram introduction exercise

STAGE 3: DIAGRAM DESIGN EXERCISE: In this last section the research team does a short introduction to diagrammatic exercise and the nature of abstract drawings. Participants are requested to develop a similar exercise to the one carried out in Stage 1 and are given a similar site plan (two options, large and small as shown in base drawings 4 and 5 in figure 2) for the detail area. The participants are asked to produce diagrammatic sketches of their proposals, focusing on the character they intend to obtain. They are encouraged to write or comment about this character and annotate it in the drawing. For the case of the second school (afternoon session) the introduction to the exercise was carried out making a stronger emphasis on the need to make single-line drawings and avoid double line sketch maps or the representation of objects.

## 3.3 Results

All drawings were reviewed and categorized under one of the drawing typologies previously introduced. Statistical analysis of the occurrences of these drawings was carried out for each of the stages of the experiment.

We begin the analysis by looking at the tendency of participants to make drawings without any particular form of briefing or training on architectural design or diagram development (Research question 1). For the initial stage of the experiment, when participants were asked to draw on a blank canvas, most of the production would sit in the typology of “objects” (type 1) and “section” (type 2) with few or none of them making a plan or abstract drawings that could be considered

diagrammatic. When asked to draw on a plan, most users would draw either Type 3 (sketch map) or Type 4 (sketch map subdivision).

These results seem to indicate that in the absence of other constraints, participants would typically draw objects or sections with fewer proposals laid out in plan forms. When asked to draw on a paper with the site plan, participants are likely to use conventions from maps similar to sketch maps. It also shows that participants don't think of the city in terms of a network of connected elements (ie, what are the links between the nodes they are interested in) but more in terms of the things they see or situations they experience.

We then move to compare this dataset with drawings produced after the introduction to diagram development. Figure 4 (left) shows a comparison of the types of drawings before and after a briefing on diagram development.

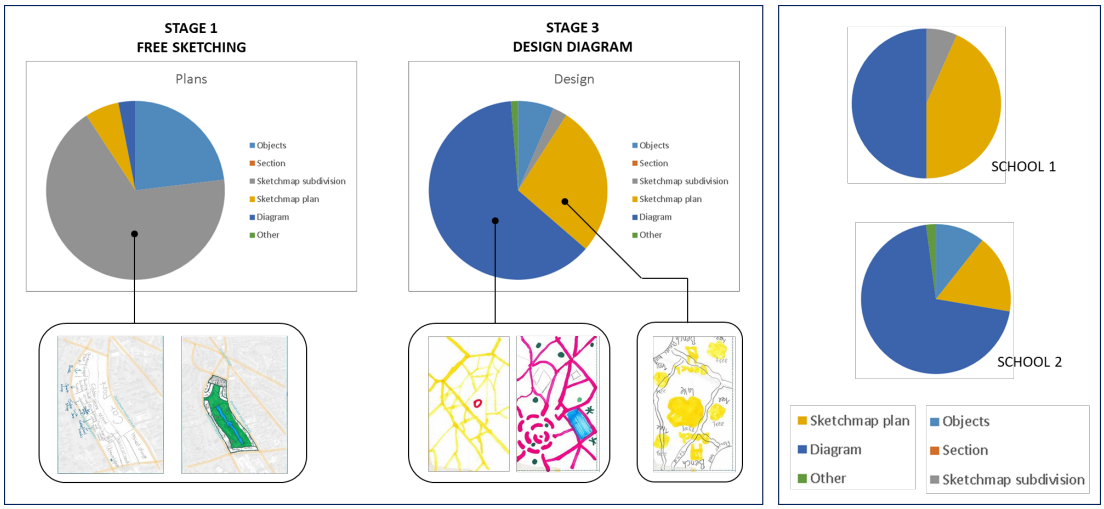


Figure 4 Statistical analysis of drawings by categories for all entries (left) and divided per school (right)

After the introduction to diagram development and when asked to draw diagrammatic proposals for the site, the use of diagrams was 65% overall, suggesting that this type of user understands the nature of diagrammatic sketches as design tools when properly introduced to these. This was complemented with a 25% usage of sketch maps. The difference between schools, where different briefs were used to introduce the last exercise was also marked. While the adoption of diagrammatic sketches remained around 50% in School 1 it went up to around 75% in School 2 (Figure 4, right). This can be attributed to a stronger, more dedicated briefing regarding the nature of diagrams, insisting on the need to avoid objects and using single-line path representation.

During the event and after some of the attempts of collective drawing via ant walk experiments, the response of the participants towards the identification of landscape style and nature of line drawing seemed clear. Participants answered questions such as "which type of landscape would this area refer to" in a manner that the author perceived to be accurate. During the abstract

drawing exercise (Stage 2 group work with 4-page subdivisions), 20% of the drawings produced were marked by trying to guess the landscape character of the lines (figure 5 left). The view of participants would coincide 70% with that of the researcher, suggesting that there was an understanding of the relation between style and the diagrammatic nature of drawings.
During the final stage (Stage 3 design with diagrams) 12% of proposals declared a style to be deployed in the diagram to then follow it. Moreover, in a small number of cases (around 2%), the participants also developed a small paragraph reasoning the choice of style and range of scales (Figure 5 right).


Figure 5 Sample results from diagrammatic exercises

Few drawings overall could be categorized as Imaginative or depicting highly irregular uses (flying cars, helipads, animals, rooftop swimming pools or similar). These were more linked to sections or objects than plans or diagrams. This would seem to indicate that the space of the imagination in terms of programs and land uses, seems to be produced without the constraints of geometry, which can be attributed to plans or diagrams with the site being represented.
The proportion of drawings portraying imaginative uses even after the activities of the workshop is particularly low if we compare it with some of the workshops carried out in architectural creative environments. This should come as no surprise since the questions asked were quite pragmatic driven (landscape design-oriented) and the drawing type lends itself to discussions on space and texture and less to narrative and storytelling.

## 3.4 Conclusions from Pilot Study 1

When we look at Research Question 1 (drawings likely to be produced by participants) A review of the drawings produced in this first pilot study would indicate that, when asked to develop generic drawings, young children are likely to think in sections or represent objects in a white space. However, when asked to use a plan of the site, they are likely to borrow conventions from traditional map representation like double lines for roads or concentric circles for roundabouts.

When moving to develop diagrammatic exercises (Research Question 2), evidence suggests that young kids are likely to understand the nature of diagrammatic sketches and make these types of drawings to express themselves if requested to do so. Briefing and clarity in the exercise request

have a strong effect on how this work is carried out and clear instructions are required to prevent participants from defaulting back to sketch maps. Given a proper introduction and training we can see how children aged 10-11 are likely to develop diagrammatic drawings and understand the relation between style and the nature of the drawing. In limited cases, the drawings are likely to be of a very good standard and serve well the purposes of urban and landscape design.

# 4 PILOT STUDY 2: DEVELOPMENT OF DIAGRAMS USING PAPER AND DIGITAL TOOLS

In a second pilot study, we begin to understand the influence of digital drawings in the entire participatory process. We do this by developing a digital sketching tool that is deployed during exercises with kids 10 to 11-year-old, in similar conditions Pilot study 1. This tool was deployed alongside traditional drawing techniques and this was done at different times during the exercise so that we could study its influence in different conditions.

## 4.1 Context

Two sites were used for this second pilot. The first site is located in Folkstone where we collaborate with the "Little Architect" (Ruiz, 2018) organisation and Creative Folkstone to develop a series of drawing workshops to increase the architectural awareness of pupils regarding architecture and sustainability, taking as a site example the redevelopment of the Ford Road Gasworks area. The site is located close to the three Primary schools where we carry out the different drawing sessions. These are Mundella, Christchurch and Stella Maris. This is a large site that hosted several gas storage tanks in the past. It is now abandoned and closed to the public and there are several talks for its redevelopment and reintroduction into the urban fabric. The site has an approximate dimension of 150mx120m and has a nearly 10m level difference (figure 6 left). It can be divided into upper and lower sites divided by a retaining wall. The lower site hosts a circular sculpture with the shape of an old gasholder and can be accessed upon request. The upper area could not be accessed at the time of developing the experiment. The two sites (upper and lower) are subject to separate drawing exercises at two scales.


Figure 6 Context of the proposals

The second site is located in London, within Hampstead Heath. The site is a small area (100mx50m) close to Heathside Primary School where we carry out a design exercise with students where we ask them to develop drawings for the redesign of a play area which is

frequently used by the pupils. In this last case, there is no formal project or proposal for redevelopment (figure 6 right).

In this second pilot study, the total number of students engaged was aro8nd 150.

## 4.2 Tool description

We developed a tool that would allow users to carry out a similar exercise to the paper drawing one, in this case on a digital canvas by drawing connective paths using single-line strokes and introducing land uses by using colour-coded lines. The user can then obtain feedback on issues of urban connectivity and landscape design. The application could be deployed on a single machine, either a laptop or a tablet (see figure 7 for layout and workflow)

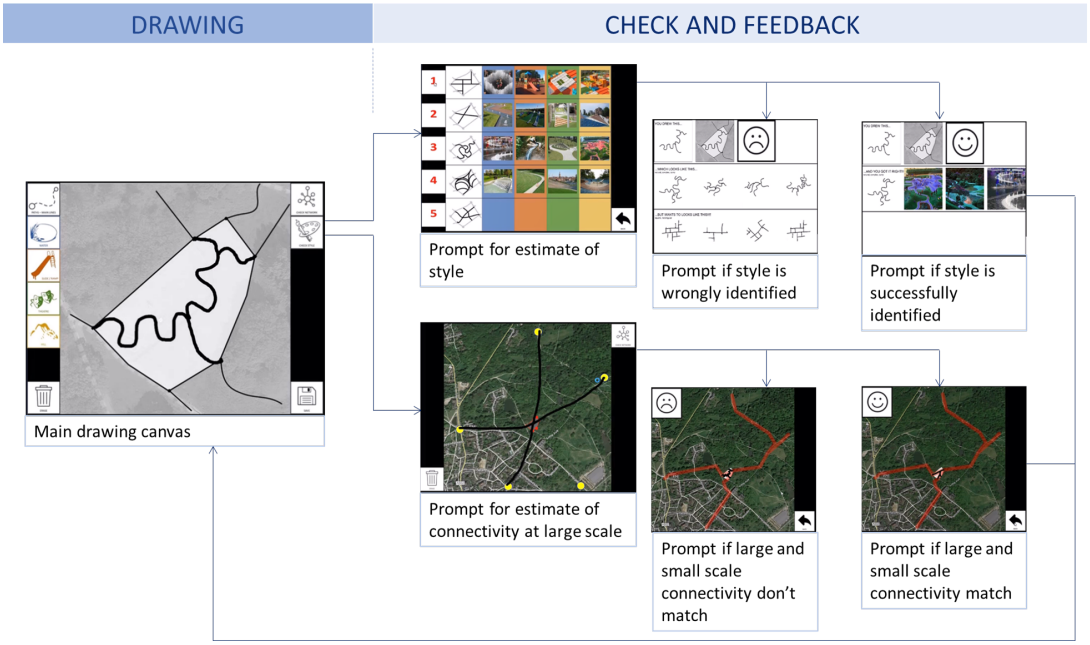


Figure 7 Tool layout and workflow

The overall exercise performed with the tool is that of developing a diagrammatic sketch of a park or playground based on its paths (desire lines or road centre lines) and different land uses (hatches or bands of lines). All of these are done using a virtual canvas 700pixelx700pixel with the site as a background image where the participant can draw with the mouse pointer or finger touch on a smart device to generate 7pix wide lines representing connection lines (black) or other land uses (coloured lines). The interface is designed to allow simple use with minimal explanation from the design team. It works on a single screen so that all feedback and navigation take place without the need for scrolling. Buttons are located on either side of the canvas (drawing tools left and feedback on the right). The tool allows for the drawing of land uses and lines at any given point and all the tasks and checks can be performed within the same step. When feedback is requested, this takes the form of a screen sliding from the left that prompts a request for a guess from the user and the result is shown on a third screen that slides from the right.

When pressing the style feedback button, a screen appears showcasing a catalogue of styles (4 in total) where sample diagrams are placed alongside the images of parks that could be generated with such patterns. A prompt asks the user to guess what style he/she prefers for the park layout and experience by clicking on the diagrammatic icon. The interface then carries out an analysis of the drawing as a raster, extracting features from a VGG19 pre-trained neural network. It then finds the closes sketch in the database to extract a predicted category (figure 8). An initial version of stylistic feedback was deployed where the tool would indicate the style of the outcome by comparing the sketch to the drawing database and informing the participant about the potential outcome "based on the sketch your landscape would look like this". In the second feedback version, the participant is asked to guess the style of their sketch (this is the version shown infigure 7). The application carries out a style guess as in the previous section and shows it on a screen with a success/failure message. In case the drawing is similar to the desired pattern, a success message appears (smiley face). If the drawing is not similar (ie the user drew one style but declared he/she wanted another) a failure notification appears (sad face) and a third row is included with sample drawings of the selected pattern suggesting a re-draw.

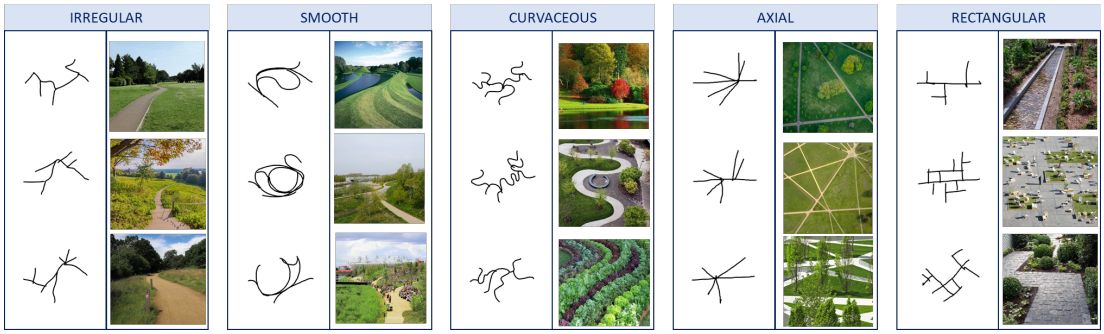


Figure 8 Landscape style categorisation according to drawing style

In the case of the connectivity check, the user is asked to guess the role of their drawing in the wider network. A larger plan of the site appears which has the site indicated as well as a series of points of interest in the vicinity. The user is asked to draw the connections that are deemed more important with a line sketched over the map. The interface evaluates the two most direct connections internal to the park and sees whether these correspond to the connections drawn at a larger scale. If the user has made drawings that would point to these connections, a success message appears, alternatively, an error message appears suggesting a redesign. After any of the feedback exercises the user goes back to the same drawing board and can either amend the drawing or submit and finish the exercise.

## 4.3 Experiment Development

After the initial concept of the tool was finalised, this was deployed under different conditions to improve its performance and also compare how it works under different circumstances. To do so, several drawing sessions were organised and an introduction to the drawing exercise was given, altogether with clear instruction for diagram development and use of the digital tool.

Session 1 took place on the 29th of May 2019 and the 3rd of June on a one-to-one basis where participants were asked to spend 5 minutes on the exercise where the briefing and explanation of the exercise were given initially to each student. In Session 2 we use a version of the feedback tool where the participant is asked to declare their desired style and the interface responds with a happy/sad face. In Sessions 3 and 4 we introduced the exercise to the entire class and circulated two devices for individual teams to carry out a digital exercise in parallel to the paper drawing. Session 3 was centred on the larger area of the Gasworks site and Session 4 on the smaller area.

Sessions 5, and 6 were done fully in paper format without the use of the digital tool. Session 5 referred to the large Gasworks site. Session 6 was a short session that had the purpose of designing a small playground in an area adjacent to their school. Students were asked to draw a context and constraints map and then develop their diagrammatic drawing. Finally, Session 7 took place with students drawing a playground for the small area of the gasworks where individual teams could use a large screen to test the interface simultaneously.

Session 8 takes place on 7th July 2019 in Heathside Preparatory School where the students are given the task of drawing alternatives for a playground close to the premises of their school. In this session, digital tools (laptops), as well as large screens, are alternated with paper drawings. An extra introduction to diagrams is given in the form of a digital tracing exercise where participants are asked to trace lines over existing parks using a digital tool. This should help students to familiarise themselves with the work of path development as well as the scale of landscape design.

## 4.4 Analytic methods

For this second pilot study, we customize the analytical tools developed in Pilot Study 1 and we incorporate aspects of quality and tool engagement. These are the following:

- Drawing categories: We use the same categories for the type of drawing (from object to diagrams) that we outlined in Pilot study 1 as shown in figure 1 to understand the level of abstraction developed in the drawing exercise.
- Drawing quality: We develop a qualitative assessment of drawings according to how well they could fit an urban proposal. We would typically consider good drawings those making longer and continuous lines that try to build some connections across the site. Partial drawings or object doodles are considered of lower quality for this exercise. Figure 9 shows some examples of these quality criteria.
- Drawing depth: For the tool-based drawings we count the times that a user requests feedback as a measure of engagement or learning. A higher number of requests and attempts would suggest more engagement with the exercise.

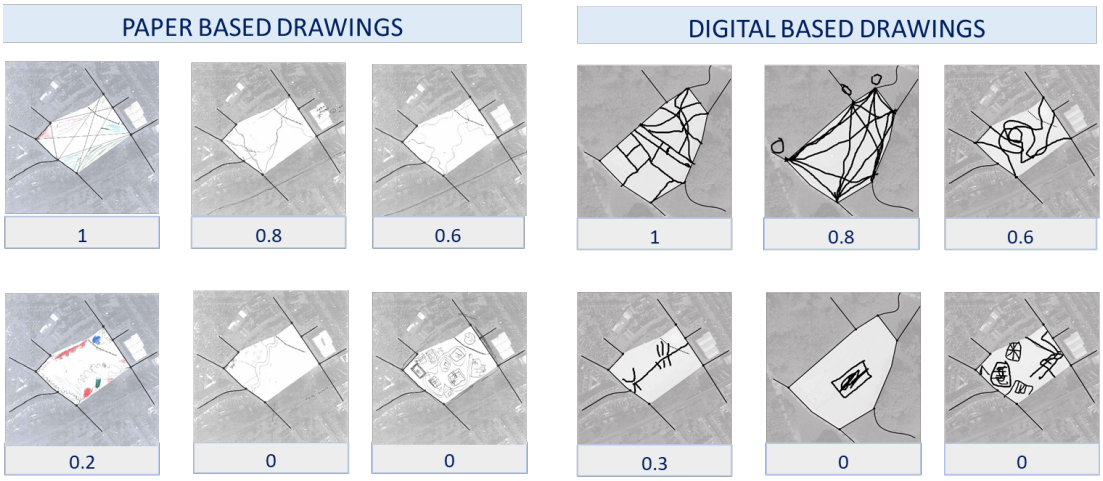


Figure 9 Drawing quality criteria (1 = good, 0 = poor)

## 4.5 Experiment Results

A total of 218 drawings were collected as part of this second pilot study (143 paper drawings and 75 digital drawings). An indication of the results related to the deployment strategy previously described is shown in figure 10. The following paragraphs develop a detailed analysis of these results and extract relevant conclusions.

| EXERCISE CODE | SESSION | COHORT SIZE | INTERFACE /MEDIUM | DEPLOYMENT | VALID DRAWINGS | 1 - OBJECT | 2 -SECTION | 3 -SKETCH MAP - SUBDIVISION | 4 - SKETCH MAP - PLAN | 5 - SPATIAL DIAGRAM | LINE QUALITY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | N | % | % | % | % | % | % |
| 1_PC | 31st May 2019 | 30 | Laptop | one to one | 11 | 0% | 0% | 0% | 9% | 91% | 91% |
| 2_PC | 3rd June 2019 | 30 | Laptop | one to one | 21 | 0% | 0% | 0% | 0% | 100% | 70% |
| 3_AN | 12 June 2019 / morning | 30 | Paper | parallel | 29 | 0% | 0% | 7% | 7% | 86% | 74% |
| 3_TAB | 12 June 2019 / morning | 30 | Tablet | parallel | 9 | 0% | 0% | 0% | 0% | 100% | 82% |
| 4_AN | 12 June 2019 / morning | 30 | Paper | parallel | 29 | 0% | 0% | 3% | 7% | 90% | 97% |
| 4_TAB | 12 June 2019 / morning | 30 | Tablet | parallel | 10 | 0% | 0% | 0% | 0% | 100% | 100% |
| 5_AN | 12 June 2019 / afternoon | 30 | Paper | independent | 22 | 0% | 0% | 5% | 18% | 77% | 84% |
| 6_AN | 12 June 2019 / afternoon | 30 | Paper | independent | 27 | 7% | 0% | 15% | 15% | 63% | 75% |
| 7_AN | 12 June 2019 / afternoon | 30 | Paper | parallel | 24 | 0% | 0% | 8% | 17% | 75% | 90% |
| 7_TAB | 12 June 2019 / afternoon | 30 | Large screen | parallel | 7 | 0% | 0% | 0% | 0% | 100% | 100% |
| 7_LARGE | 12 June 2019 / afternoon | 30 | Large screen | parallel | 3 | 0% | 0% | 0% | 0% | 100% | 100% |
| 8_AN | 7 July 2019 | 15 | Paper | parallel | 12 | 0% | 0% | 0% | 0% | 100% | 97% |
| 8_PC | 7 July 2019 | 15 | Laptop | parallel | 11 | 0% | 0% | 0% | 0% | 100% | 94% |
| 8_LARGE | 7 July 2019 | 15 | Large screen | parallel | 3 | 0% | 0% | 0% | 0% | 100% | 100% |
| Total papel drawings | | | | | 143 | 1% | 0% | 7% | 11% | 80% | 86% |
| Total digital drawings | | | | | 75 | 0% | 0% | 0% | 1% | 99% | 87% |
| Paper dawings performed independely from digital tool | | | | | 49 | 4% | 0% | 10% | 16% | 69% | 79% |
| Paper drawings performed in parallel to digital tool | | | | | 94 | 0% | 0% | 5% | 9% | 86% | 89% |
| Digital drawings performed with a laptop | | | | | 43 | 0% | 0% | 0% | 2% | 98% | 81% |
| Digital drawings performed with a tablet | | | | | 19 | 0% | 0% | 0% | 0% | 100% | 92% |
| Digital drawings performed with a large screen | | | | | 13 | 0% | 0% | 0% | 0% | 100% | 100% |
| TOTAL | | | | | 218 | 1% | 0% | 5% | 8% | 87% | 86% |

Figure 10 Deployment stages and drawing results

Comparing the total set of paper-based drawings and the digital dataset shows that the digital tool influenced heavily the type of drawings being produced, with the students consistently generating diagrammatic drawings in almost all of the cases (99%), which is higher than the case of the paper drawings (80%). This can be attributed to the nature of the digital interface. In this case, the digital canvas produced 7 pixel wide drawings over a canvas of 700-pixel x 700-pixel which may have proven inconvenient for the development of details. Constrains in the sketching tool, therefore, seem to favour simple and schematic drawings.

We can then look at the interrelation between digital and paper drawings. If we look at the type of drawings that the participants produced when there was no tool being used, we found a proportion of diagrammatic drawings not too dissimilar from the case of Pilot 1, with an average of 69% being diagrammatic. However, if we measure the nature of paper drawings that were being produced alongside the digital tool, we can see how this proportion goes up to 86%, which is higher than the average. This can be attributed to the fact that the explanation of the tool usage and the curiosity it produces may influence participants to change their design and imitate the digital drawing.

The average quality of the drawings follows a similar pattern, with digital drawings having a slightly higher score (89%) than paper ones (79%). When comparing the quality of different digital devices we can see how the quality of the drawings increases from 81% using a laptop to 94% using a tablet and 100% using large screens. This was to be expected since the operation of free drawing seems more natural when performed with the finger or the freehand.

We now look to a grid composed of all images to understand if there are patterns that help us understand how the users behave with different devices (figure 11). Drawings produced with large screens tend to have a higher predominance of long smooth curves, while those done with laptops present more jagged, shorter lines. These also took longer to produce, while larger formats encouraged faster drawing. Tablets and Large screens also encouraged double tracing and the development of more lines than those carried out with a mouse on a laptop.

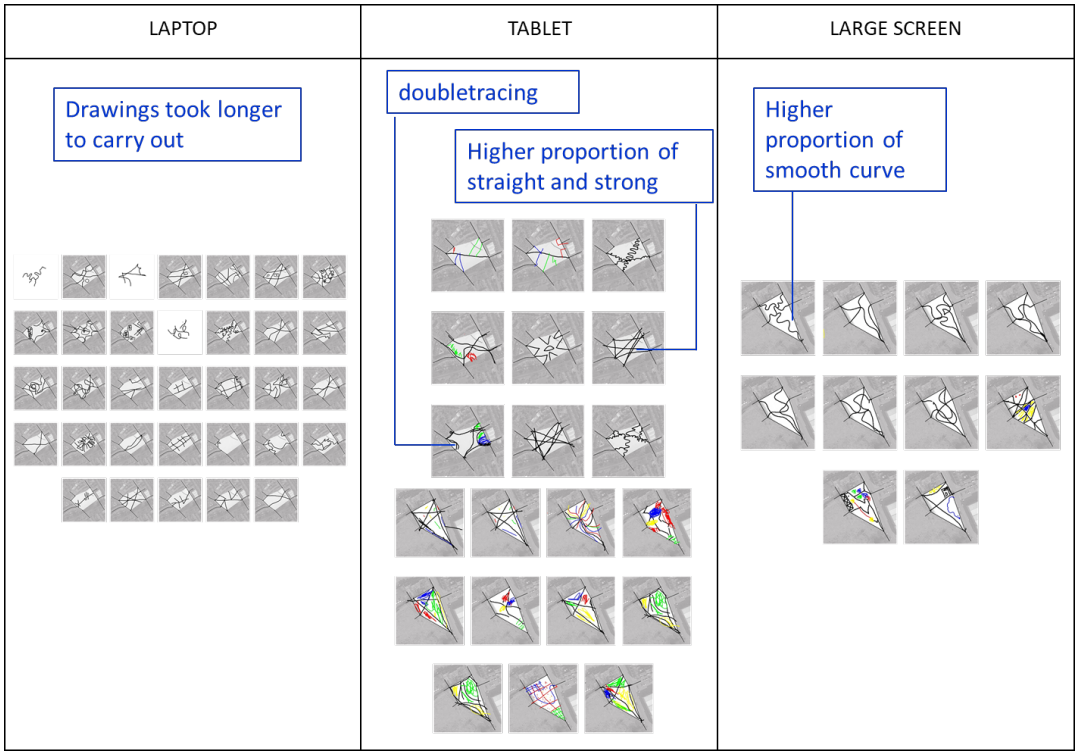


Figure 11 Drawing characteristics per exercise

We now move to analyse the engagement related to the feedback provided by the tool. We use the value of usage depth (number of interface uses as previously mentioned) as a proxy for the amount of time and effort spent with the interface When comparing Session 1 and 2 we can see that the depth grew from 1.2 to 2.1 (figure 12), which is almost one more feedback request per usage. This can be attributable to the different types of feedback formats given by the tool versions. While in Session 1 the tool would simply provide a statement of the potential outcome, the feedback in Session 2 was more a guesswork game with a clear objective. This proved to engage participants who tried to get it "right" with several attempts. It has to be noted that the final result was not necessarily better than the initial one in terms of drawing quality, but it tended to match more the chosen reference style.

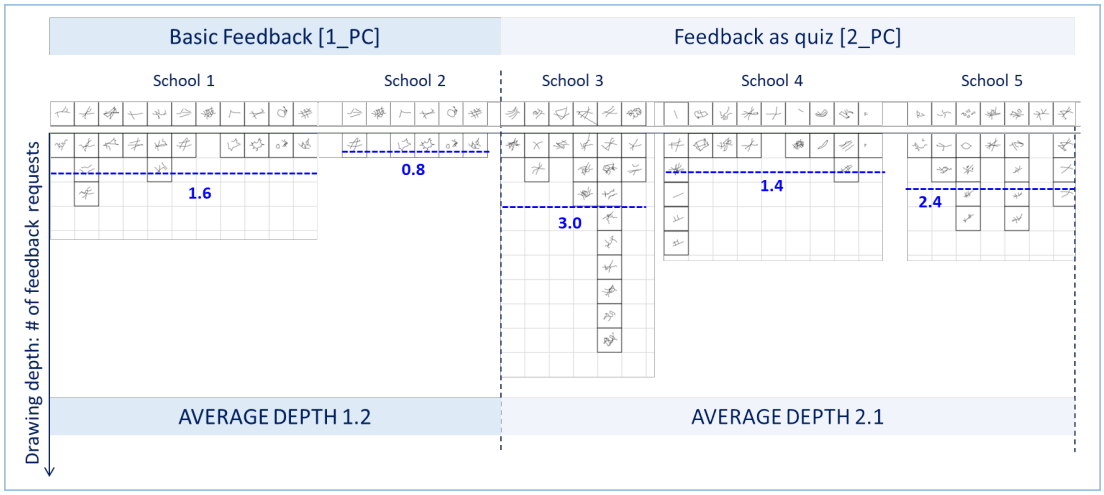


Figure 12 Drawing depth per exercise

When considering the number of participants per session, we observe a positive impact of having a reduced cohort. In session 8, the student number was smaller (15 in total) so there was more access to the drawing tool, mounted in a laptop as well as a large screen. In this case, another interface was circulated with the park tracing tool. This helps to explain a slightly better quality of drawings (96% on average) altogether with a higher proportion of abstract/diagrammatic drawings in the proposals (100% in this case).

### 4.6 Conclusions from Pilot Study 2

A review of the results indicated that the usage of the digital environment shifts the production of drawings towards a more abstract-diagrammatic realm when compared with other drawing mediums (Research Question 3 on the influence of online tools). It can be seen that the tool has an influence even on other forms of production such as paper drawings if it is used in parallel. This can be relevant when thinking of using this type of technique in combination with other forms of drawing or consultation, where the digital environment is likely to prompt different responses from the audience. We also observe a positive effect on engagement from feedback if there is a clear objective behind it (Research Question 4 on the effect of feedback). Users are likely to observe the feedback and, in case there are clear success criteria, take the exercise as a challenge and improve their input. Experience shows that devices that allow for an easier input will encourage longer, continuous and more numerous lines. This can have stylistic implications with lines being longer and smoother and, in some cases, over sketching.

## 5 OVERALL CONCLUSIONS

Our work proves that children aged 10-11 can understand how to carry out diagrammatic drawings and use this technique as a form of participatory design. This happens in particular when adequate briefing is provided and is strongly encouraged by the use of digital tools, opening the door for the deployment of this form of interaction as the basis of DPPs showcasing SS analysis.

Evidence suggests that diagrammatic drawings do not come naturally from children, who are most likely to draw objects, sections or maps (Research question 1). However, it is nevertheless reasonable to expect that basic forms of diagrammatic expression can be achieved through the proper briefing (Research Question 2), particularly when emphasizing the need to observe single lines similar to desire lines and clear connections. We also saw how the use of tools that constrain the quality or detail of the drawing can move the results toward a more abstract and diagrammatic level (Research Question 3). We could also see how feedback can be an important factor to “hook” or engage the user further if adequately introduced (Research Question 4). However, we could also see how the information provided in the app could be easily misinterpreted or ignored. If the problem is not very well formatted (ie there is not a clear objective and a way to achieve it) the user is likely to ignore it and will not have positive learning or engaging effect. We could also observe that framing the exercise too openly (giving too many

tasks simultaneously) can prove to be disorienting for the participant. While designing is a task that does not necessarily have a clear sequence or success criteria, it may be necessary to bring some of these aspects into the interface so that at each step, the user knows what needs to be done, and how it can be measured and ultimately amended.

Diagrammatic drawing can, therefore, reach a new audience and find new ways of enquiry our perception of space, particularly through a configurational approach. This research also points at the possibility of using SS theory in educational environments thanks to intuitive and easy-to-use interfaces that young children are likely to use. More research could be carried out on the analysis of the configurational nature of these drawings, comparing them with professionals or across age groups. This can help understand how people understand space through different ages, but also help popularize this theory across the widest possible public.

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