555

Drawscapes

Study of the effectiveness of online diagrammatic sketching in participatory design

EDUARDO RICO, & KAYVAN KARIMI

UCL, LONDON, UK

ABSTRACT

The increased user-friendliness of Space Syntax (SS) packages and their improved compatibility with popular 3D modelling software has pushed the use of Space Syntax Theory (SST) into the professional realm, making it approachable, not just by dedicated researchers, but also to an increasing number of practitioners. We argue that the applicability of SST can even go further if we use sketching as a form of interaction with the software, potentially opening up its use to general members of the public as part of a wider participatory process. We present a study that tries to understand whether the diagrams required for this form of engagement are easy to produce by non-professionals and once they are produced, see whether they have an impact on the planning process.

We propose an experiment using an online design tool that allows participants to make drawings of urban proposals by drafting simple diagrams, beginning with connective paths followed by urban blocks using thicker versions of the same pen tool. We develop bespoke analytic methods to extract general patterns emerging from data, identify trends across different user groups, and study user interaction, design quality and user engagement. We take the expansion of UCL East as a case study and test our tool with several participant groups from the general staff and student population as well as external design professionals. Some of these professionals carry out the exercise after reviewing the design from UCL members. We obtained 700 drawings from 400 participants and carry out comparative studies across groups. The study concludes that general members of the public can understand the type of drawing exercise requested and produce designs of an adequate standard. We can also see that planners and architects observe positively the information coming from general members of the public and are willing to incorporate it into their designs.

KEYWORDS

Participation, Sketching, Digital Engagement

1 INTRODUCTION

Space Syntax (SS) practice was developed by Hillier (Hillier, 1996) and Hanson (Hillier and Hanson, 1984) as a theoretical study on how the city's configuration relates to the human perception of space and ultimately to the levels of activity and vitality in architectural and urban space. Its applicability across all scales of the built environment (Penn et al., 1998) has granted it a distinct place in the research world (Karimi, 2018) and a growing weight within transport planning (De Koning et al., 2017), urban retrofit (Karimi and Parham, 2012) as well urban design (Karimi, 2012), (SSL, n.d.), (van Nes and Yamu, 2021) since it reassures practitioners of the potential success of their schemes, flagging out problems or helping them identify the best solutions for spatial layouts. This explains the growing popularity of this theory in the practice world, where the number of offices using SS tools and methodologies has recently experienced a great increase with a large community of practitioners and research growing worldwide (Space Syntax - Network, n.d.).

From a user perspective, the translation of design features into graph-ready attributes is a key factor for the applicability of SST to practice. The original SS toolkit (Depthmap, n.d.) and its current version (DepthmapX, n.d.), were thought primarily for GIS integration. Over the last years, SS tools have been developed with a simple interface (AGRAPH, n.d.), but more importantly, integrated within 3D modelling packages which are more popular within the urban design environment such as Rhino-grasshopper (grasshopper3d, n.d.). Several libraries have been published over the last years (DeCodingSpaces, 2021), (Nourian and Groups, n.d.), ("SpaceChase," 2021), ("SpiderWeb," 2011) that allow practitioners to tailor their design pipeline and visualize the SS indicators of their proposals as they carry modifications and tweaks to their schemes, almost in real-time. Moreover, the generative nature of these packages, including parametric design (Schaffranek, 2013), genetic algorithms (Li et al., n.d.) and others, allow for multiple option testing and optimizations as part of the refinement process.

The move to include SS in 3D modelling tools has allowed the expansion of SST to a wider number of practitioners. However, both these tools, namely GIS and 3D modelling, are still restricted professionally and socially to a narrow band of users that need to be familiar with design software interfaces and drawing conventions used in either GIS environment or 3D modelling ones. Operations carried out when navigating the model, such as using the mouse for zooming, panning, rotating (orbit or similar) may not be easy grasped by non-users. More crucially, principles behind drafting, such as snapping thresholds and questions on the accuracy of line intersections and junctions, are likely to generate further barriers for non-experts. Other forms of input can be explored, namely hand-drawn sketches, which could prove a further gain in the reach of SS theory and, potentially, enable general members of the public to express their opinion on the configuration of the city via simple means. We argue that using this sketch-based approach, SST and other forms of evidence-based design, can reach the general public as a form of consulting about urban proposals, in what is typically known as design empowerment (Senbel and Church, 2011).

This move of empowering participation through digital design tools would fall within what some scholars such as (Falco and Kleinhans, 2018) call Digital Participatory Platforms (DPPs). These tools, in many cases deployed online, can take the shape of drag-and-drop methods, basic collage canvases or paths in maps, and many cases provide live feedback from design actions. This combination of ease of deployment and increase in design outreach opens a large opportunity for participatory planning to expand its relevance and produce an effective process of co-design.

However, several questions remain still open for design-based DPPs to fully claim a space within the repertoire of participatory tools. While there is data on the user experience of some of these tools (mostly 3D based) and insightful assessment of the analytic techniques of the results, there is not enough evidence on how the data being obtained via these design methods is later used in a longer-term process. Questions on how planning professionals read data coming from DPP surveys and how this finds its way into the final proposals are still open and require research work to be answered. Other questions are more specific to the type of design material we want to focus on, namely diagrams of urban form. Given the abstract nature of diagrams, it is not clear whether users are going to understand them as a form of expression and engage with them properly.

As a result, research needs to understand the full potential of this type of drawing as a form of collaborative design with general members of the public. This paper addresses these questions on the potential use of diagrammatic sketches as a form of participation, addressing issues of usability of diagrams, learning experience and ultimate effectiveness of these tools.

2 LITERATURE REVIEW

In this section we review the current work carried out in the field of DPPs, identifying their position within participatory practices as well as current techniques to study the result produced in these tools. We then review methods to evaluate DPPs, which helps generate the research questions followed in the rest of the study.

2.1 Digital Participatory Platforms

Improvements in the interactivity of web-based platforms have allowed survey platforms to incorporate design as a form of participant input, bringing the idea of "design empowerment" (Senbel and Church, 2011) to a larger scale data gathering environment. Authors such (Falco and Kleinhans, 2018) talk of Digital Participatory Platforms (DPPs) as tools with a strong emphasis on co-production and review 113 DPPs according to how much they push ideas of co-creation. More recently (Gün et al., 2020) look at recent DPPs practice and review the 25 most prominent examples assessing how these tools empower citizens in the design process. While the majority of DPPs analysed in these studies could also be classified within the category of Public Participatory GIS (PPGIS) and Volunteered Graphic Information systems (VGIs), a small proportion would go “an extra mile” regarding the introduction of design actions, including image treatment, 3D object manipulation and spline sketching.

Engaging with an urban design scope, (Müller et al., 2018) deploy an interactive design kit called qua-kit (qua-kit.ethz.ch, 2020) based on a 3D interactive drag-and-drop environment where users can place buildings and several objects on a white canvas representing an area of the city while they receive feedback on user area and statistics. (Mueller et al., 2020) develop ideas on how to improve and enhance the user experience by reducing unnecessary steps, clarifying UX and moving to a “straight to the point” approach with supplementary video context information. The authors also detect a substantial benefit in providing feedback on design parameters to the users accessible during the exercise. Furthermore (Müller, 2021) proposes three levels of analysis of user data, starting from basic feature extraction (areas or similar), kernel density finishing with point-based correlation identifying items typically placed close by. (Lu, 2018) further use qua-kit to correlate use patterns with participant background information. They equally found that users could understand the abstraction levels behind Quakit-usage and were also interested in the understanding of feedback on their proposals. This type of work has not passed unnoticed by large software providers such as CityPlanner (Bentley, 2020) letting users either sketch lines or add blocks in an urban environment, allowing other users to review alongside comments in a GIS-based environment. These have been deployed in cities such as Stockholm and Goteborg. Equally, (ESRI-ArcGIS Urban, 2020) offers an interactive environment where users can add and remove objects while receiving live feedback on relevant parameters.

DPPs have also been developed working more closely with a syntactic approach, focusing on the development of lines and paths. (Zhang et al., 2019) use a GIS interface to enable users to sketch preferred paths around a series of lakes in Wuhan to then develop a survey-based study of usefulness. The users are given the chance of drawing route paths and locate key uses in a map of Wuhan lakes for a site around 15km wide. The authors use heatmap analysis to represent user preferences in land use location as well as graphic route overlap for all options and are capable of ascertaining a relevant capacity of users to engage with the act of designing and developing a form of a diagrammatic sketch, in this case at a geographical scale. Working at a smaller scale, (Jankowski et al., 2016) combine traditional questionnaires with an interface that allows participants to draw polygons or introduce points for land-use change preferences. The authors then develop heatmaps and aggregation analysis of preferences shown on a map.

All these works share a clear drive to “let participants design” as well as trying to develop methods to analyse the outcomes concisely and understandably. There is a strong potential to expand this field of research, especially concerning how feedback from users can be used in a further generative process and data analysis. However, as some authors argue (Falco and Kleinhans, 2018), (Mueller et al., 2020), further studies are required to evaluate the effectiveness of DPPs within a participatory process, looking at the impact on planning outcomes. Moreover, the tools previously outlined focus either on a large-scale path development or an object-oriented approach at a smaller scale. SS analysis is likely to work well when used in road centre-line or desire line type diagrams and so far, has not been studied in DPPs research. This paper addresses questions on this type of DPPs, which are introduced in the following sections.

2.2 Evaluating DPPs

While the case for digital participation can be made for a variety of projects, the evaluation of its effectiveness remains still a field to be improved, particularly when referring to sketching interfaces. The evaluation of DPPs (Müller, 2021) draws heavily on previous work on Human-Computer Interaction (Nielsen, 1993), Public Participatory GIS (PPGIS) (Kahila-Tani et al., 2016) and Planning Support Systems (PSS) (Pelzer, 2017) and (Goodspeed, 2016).

CRITERIA	DESCRIPTION	INCORPORATED
General Usability on Human Computer Interaction, Nielsen, 1993		
Learnability	It is easy for users to learn to use the tool.	USER LEARNING
Efficiency	Users perform tasks once they have learned to do the tasks.	USER LEARNING
Memorability	Users remember to use the system after they have used it initially.	USER EXPERIENCE
Errors	How easily can we make errors, how severe their consequences and how can users recover.	USER EXPERIENCE
Satisfaction / Pleasing	How pleasant it is to use the tool and what enjoyment do users get out of it.	USER EXPERIENCE
General Usability of software products, ISO 9126 1998a		
Learnability	It is easy for users to learn to use the tool.	USER LEARNING
Understandability	Users can understand the tasks and context of the tool	USER EXPERIENCE
Operability	Can user control its operations	USER EXPERIENCE
Attractiveness	Can the tool please the user	USER EXPERIENCE
Compliance	The product can support standards, conventions, style guides [ISO 9126 1998a]	
PSS evaluation, Pelzer 20015		
Learning about the object	Gaining insight into the nature of the planning object	USER LEARNING
Learning about other stakeholders	Gaining Insight into the perspective of other stakeholders in planning	EFFECTIVENESS
Collaboration	Interaction and cooperation among the stakeholders involved	-
Communication	Sharing information and knowledge among the stakeholder involved	-
Consensus	Agreement on problems, solutions, knowledge claims and indicators	-
Efficiency	The same or more tasks can be conducted with smaller investments	-
Better informed plans or decisions	A decision or outcome is based on better information and/or better consideration of the information	EFFECTIVENESS
PPGIS evaluation, Kahila-Tani et al., 2016		
Representativeness	The sample of users should represent the affected public.	REPRESENTATIVENESS
Independence	Both managers and facilitators and public representatives should be independent of any affiliation.	-
Early involvement	Deployment during a phase where value judgments are formed.	-
Influence	Gathered input manages to inform the planning process.	EFFECTIVENESS
Transparency	Public see how further decisions are made and how the planning progresses after the participatory event.	-
DPPs Design empowerment, Senbel and Church, 2011		
Information	Participants gain a new understanding of planning issues and possibilities through substantive and procedural knowledge	USER LEARNING
Inspiration	Participants are compelled to act in response to the visualization material	USER EXPERIENCE
Ideation	Participants are able to generate and express and thoughts about the future of their home neighbourhoods	USER EXPERIENCE
Inclusion	The ideas and thoughts of participants are included among the priorities in neighbourhood design decisions	EFFECTIVENESS
Integration	Participants collaborate in the coproduction of plans and proposals	EFFECTIVENESS
Independence	Participants are able to create their own independent plan visions	EFFECTIVENESS

Figure 1 Review of assessment criteria for various categories of participatory tools

Each of these authors has developed a series of indicators that help measure the effectiveness of these tools, which are included in figure 1. We carry out a systematic review of these criteria considering their Applicability to our case and group them into three main broad categories of criteria to be studied, namely criteria about how the user interacts with the interface (USER EXPERIENCE), how does the user learn about the entire process (USER LEARNING) and the impact of the tool on the planning process (EFFECTIVENESS). These three criteria are used to generate the research questions and the subsequent methodology for our current research.

2.3 RESEARCH QUESTIONS AND METHODOLOGY

A review of the existing work on DPPs has identified the main gap in the knowledge of how sketching tools can be used to complement a syntactic approach as well as the need to assess their effectiveness. The review of the existing assessment for these tools has also identified main categories of judgement criteria, namely user experience, user learning and overall effectiveness. This research and the subsequent categories of criteria help us formulate our main research question and break it down into three sub-questions:

Does the collection of diagrammatic sketches of urban form carried out by general members of the public make a meaningful contribution to the planning process?

Using the three categories of assessment criteria, we arrive at the following research questions that help us organize our research:

Research Question 1 – USER EXPERIENCE: to what extent do participants understand the exercise proposed and develop adequate drawings: We hypothesise that a good proportion of the users that access the tool understand the scope of the exercise and the type of drawings requested to develop diagrammatic sketches of an acceptable standard. We begin to answer this research question during prototype development, where an initial version of the tool is trialled with focus groups of designers and five semi-structured interviews are carried out to understand usability. In a second stage, during tool deployment, a drawing validity criterion is developed for drawings. Input from participants is tested against this criterion and this is used to estimate the proportion of participants that seemed to engage adequately with the exercise.

Research Question 2 – USER LEARNING: to what extent do the participants learn about the projects at stake while carrying out the exercise? The idea behind this question is that, when using the tool and requesting feedback, users will learn about the drawing task and adjust their drawings accordingly. To answer this research question, we develop measures of quality for the different exercises and we analyse the evolution of these measures throughout each exercise to see if the user learns and improves the drawing. We also analyse these features in an aggregate manner for entire groups of users.

Research Question 3 – EFFECTIVENESS: To what extent do practitioners incorporate information gathered from general members of the public into their proposal?: We hypothesise that the processed input from general members of the public is considered relevant by a substantial proportion of practitioners. This would mean that this information finds its way into the final proposals of practitioners in forms that can be traced or verified. To ascertain this fact, we gather data from general members of the public and analyse it to extract general trends. We develop a technique to extract two main options from the drawing dataset as well as a "map voting" canvas that allows the user to review drawings easily and select favourites. This is included in a website report that is combined with information about the project. We then organise two separate tests with participants with a design background. The first group of practitioners receive a link to the same website as the general members of the public. The second group receives a link to a website showing the results from the participation as well as the emerging options. Only after they have gone through this information, these users can then move to the design website to carry out their proposals. The design outcomes of this last group of practitioners are compared with the initial group of practitioners as well as general members of the public.

3 TOOL DEPLOYMENT AND DATA GATHERING

3.1 Project selection

We chose the current project for the extension of UCL-EAST as a case study since this would give us access to a large potential audience (UCL students and staff). The project has recently gained planning permission and due to its size and relevance to the university, it is relatively well known among the staff and, to a lesser extent, also students. More importantly, we can get access to a potentially large group of participants from UCL staff and students via UCL services. They can arguably be treated as individuals with a certain interest or stake in the project (see later section on participant outreach).

This is a large-scale urban project that will provide a 40% increase in area facility for UCL in terms of extra research space, student accommodation, common facilities and teaching area. Within the entire development, we focus on the so-called Marshgate Area, located a 10min walk from Stratford International station and less than 5 minutes from Pudding Mill Lane DLR. It is situated between two canals (East and West), DLR tracks to the south and the Olympic Park to the north. The site has a square-like shape with 200mx200m dimensions, making a total area of approximately 39,000m2 and including 4 buildings from UCLE EAST. These add to approximate 134,700m2 of the built area which translates to a Floor Area Ratio (FAR) = 4 approximately (total built area/site area).

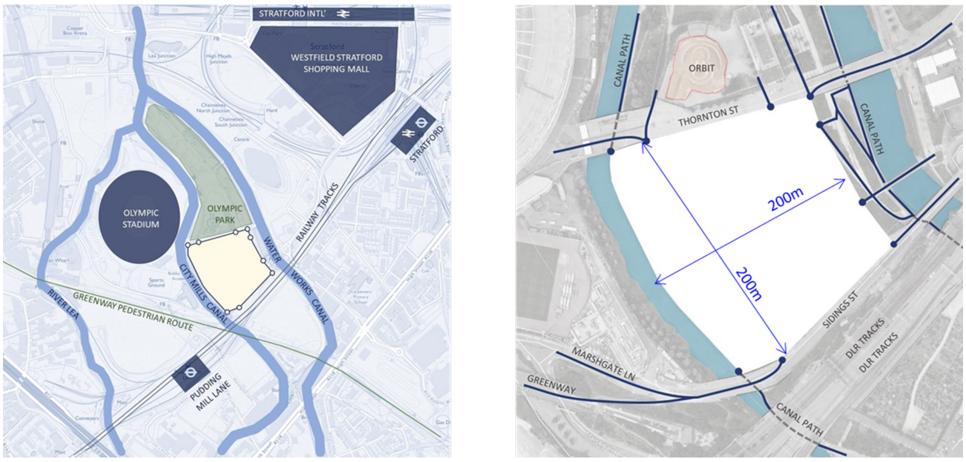

Figure 2 UCL EAST project context in Stratford (left) and Marshgate site (right)

3.2 Audience selection and outreach

The tool development took place through several experiments where the design of the user experience and the interface were tested within a reduced focus group. We then moved to large group mails to UCL staff and other groups. These were broken down so that the deployment of the tool took place in a staged manner, allowing for corrections on the layout, the information provided and functionality. It is an iterative process where small changes to the tool are tested with selected sections of the target audience and the responses of participants are analysed comparatively.

In all phases of the deployment beyond the prototype stage, participants were contacted via email or social media posts. For all external audiences, the project was referred to as Drawscapes, which coincides with the domain for the web app. The communication would typically include a paragraph introducing Drawscapes as research on participatory drawing and a link to a video that complements this information. A link to the Drawscapes tool or the introductory survey website (which further links to the interface) is also provided. Neither the mail nor post introduction nor the video gave instructions on tool usage or site details since this is all provided as part of the interface experience.

The main participant group were general UCL staff and students who were contacted via large scale mailing methods across UCL. Except for 5% of initial tests carried out with Bartlett students, there is no connection either professionally or academically and outreach is fully carried out via UCL services (marketing or others). Several faculties were contacted directly, which allowed for gradual testing of introductory information as well as layout. In all of the cases, the tool was accessed via the same link provided during mailing.

The second group of practitioners were reached outside UCL and contacted via social media. Most of the connections that were used in this research came from professional networks or professionally related connections from research and are therefore considered to have a design background. This group accessed the tool separately from other groups and data is therefore stored separately.

A final group of users were contacted via BIGDraw organisation, in this case, introduced with a post on their social media and a short article expanding on Drawscapes on their website. The participants are introduced to the exercise via a website with UCL results survey.

3.3 Tool description

The interface was designed to run directly on a browser by accessing www.drawscapes.com. It can run on any device (laptop or tablet). We did not recommend usage on a mobile phone due to the small size of the screen. It is meant to be easy to use in a step-by-step manner so that all drawing instructions and background information are provided as part of the user experience (see figure 3).

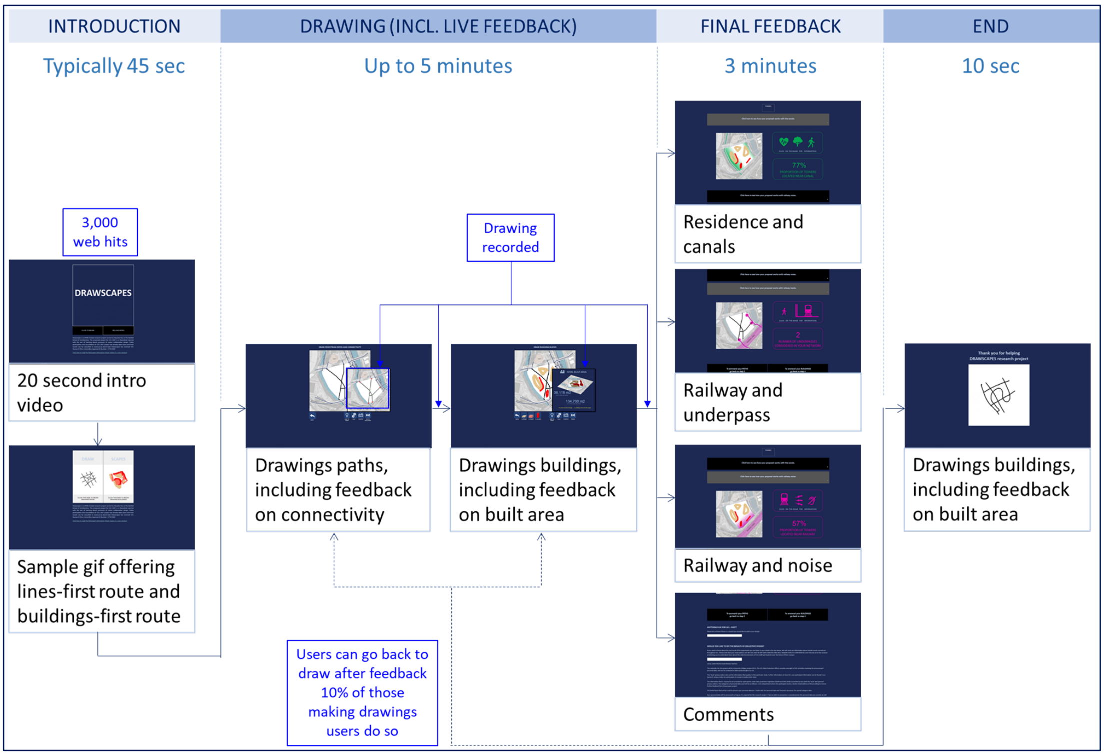

Figure 3 User experience and workflow of the digital interface

The experience is mainly conceived as a step-by-step exercise. The user arrives at a website where introductory media gives background to the site as well as what is required in the exercise. The media can be re-played for clarity or be skipped to the drawing phase. In the initial step, the user moves to the main part of the exercise where he/she is presented with a canvas where to draw paths or buildings while obtaining feedback. Two routes are available (paths-first or buildings-first) and in each of these routes drawing tools and feedback are provided related to the relevant task. Users can only advance to the next stage when at least one line has been introduced. Once the two drawing exercises are finished the participant can navigate to the final feedback section.

The user is then prompted to a final page where he/she can get to see the implications of their design with regards to connectivity, railway noise and proximity of the development to canals. This final feedback happens in addition to the immediate feedback that the participant can obtain during the drawing phase. The user can then go back to any of the previous stages if he/she wishes to do so. In this feedback section, there is space for the user to leave written comments about any other aspect that may be relevant to the project. When the user saves the data, the interface goes to a final thank you screen. It has the finality of providing a polite ending to the exercise as well as reassuring that data has been stored when closing the exercise.

Figure 4 shows an indication of the user interface. A central canvas 700pix * 700pix allows users to make drawings while a toolbar below allows for a choice of drawing type for the lines (black for paths and thick colours during the building section as shown on the left side). Tips, Feedback and Context are shown as popups appearing when hovering on the button.

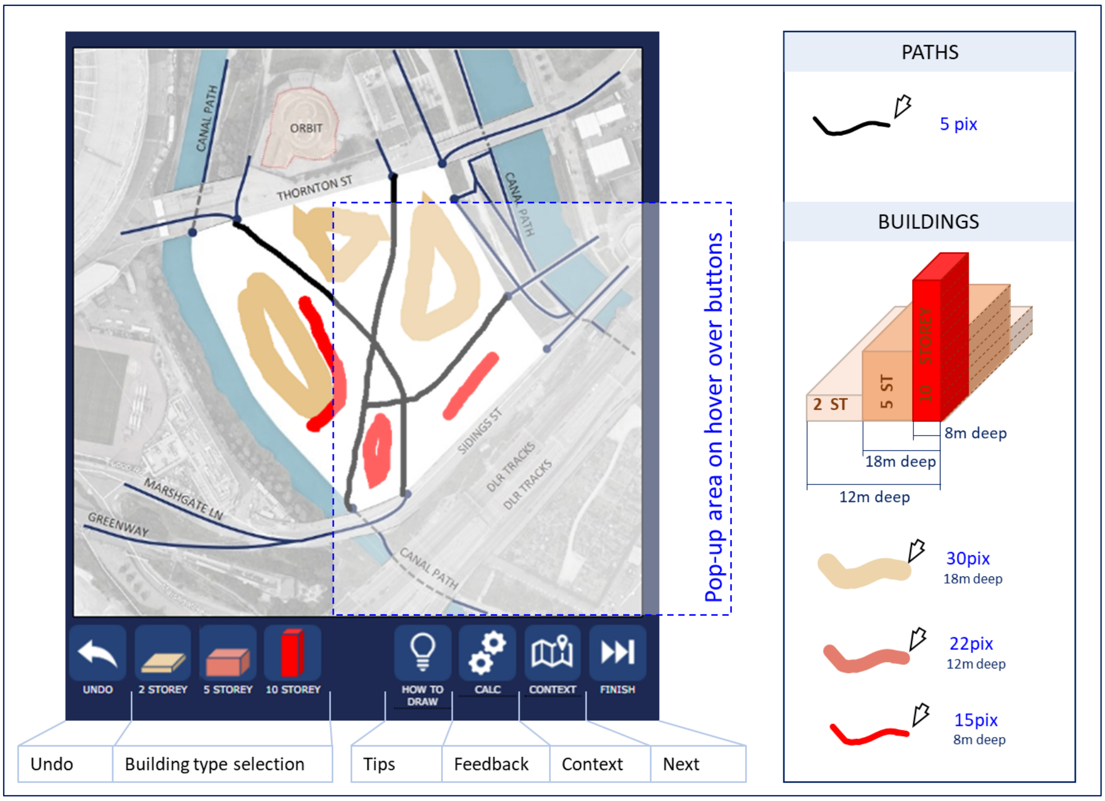

Figure 4 Main user interface

3.4 Bespoke analytical methods

A series of methods are developed to be able to analyse the results coming from the participation, namely diagrammatic sketches. We develop methods to assess the quality of individual drawings, generate group representations of various drawings and obtain overall options. these are described in the following paragraphs.

Usage ratios: We measure the number of actions that participants developed in each drawing as a measure of their engagement with the tool. This included the number of times they requested feedback from the interface as well as clicking to the next stage in the exercise.

Aggregate line drawing: This analytical method helps us understand the most straight connections suggested by the whole participant group. Lines drawn by the participant are simplified as straight segments in a graph. The shortest two connections between entry nodes are identified as a simplification of the overall connection (figure 5) for further aggregation of all participants.

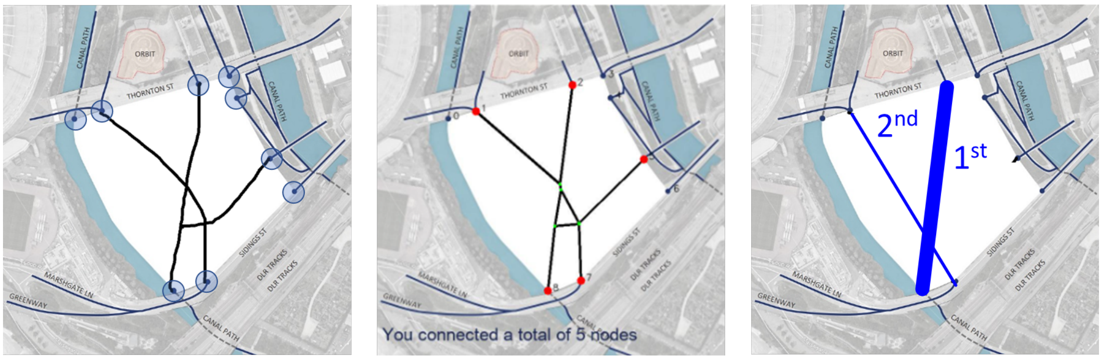

Figure 5 Simplified connection for a single drawing for further aggregation

Drawing quality and validity: Basic criteria for drawing quality are developed by the design team when considering which drawings are valid and adequate for urban design. Amongst others, drawings of objects or squiggles are considered invalid (see examples in figure 6). This serves as the basis for the manual annotation of part of the drawing set. A simplified series of geometrical features are extracted from the drawings which are used to develop an SVM classifier for image drawing quality which is applied to each entry. For the case of the building drawings, quality was defined as the ratio of buildings drawn / UCL East proposal (135,000m2).

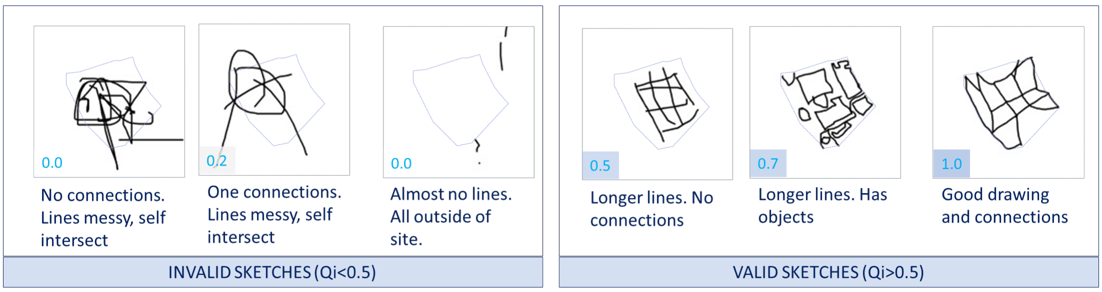

Figure 6 Examples of drawing quality

Principal Component (PC) analysis and option extraction: For this exercise, we transform all sketches into 200pix*200pix raster images and use the method of eigenvalue decomposition (sklearn, 2020) to extract the first 6 components. These components come ranked per relevance in such a way that the initial PCs will typically carry more weight than the final ones and can be considered more important. For option selection, we manually trace the stronger parts of the images (either white or black) as the main representation of lines and will look more carefully typically at the first 2 or 3 components. This method can be applied both to the path as well as building exercise (in this last case turning the building drawings into a greyscale map). See figure 11 and 12 in the result section.

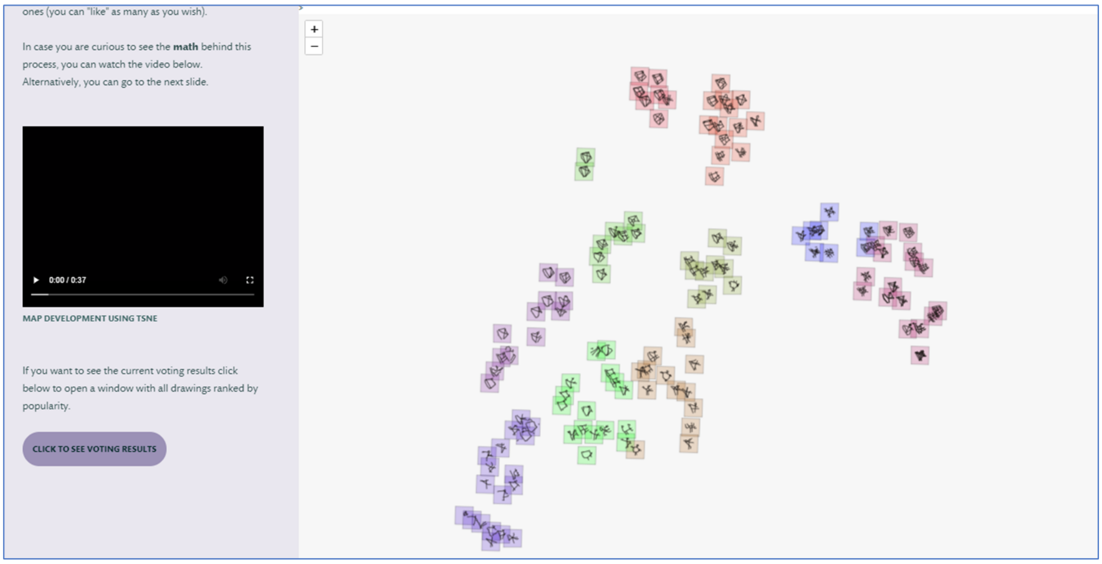

Figure 7 Drawings clustered by the graph, geometrical and image featured and represented in an interactive voting-enabled map

Geometrical analysis: Drawings from UCL participants are analysed and grouped by geometrical similarity so that they can be reviewed in an interactive map. A series of geometrical measurements from the lines drawn, as well as graph analysis and image processing of the raster image (VGG19 features). These features are blended into an overall feature generation which is fed into a TSNE dimensionality reduction algorithm, producing the final map which can be reviewed by users (Figure 7).

4 RESULTS

4.1 Analysis of user experience (research question1)

We begin analysing the results of the semi-structured interviews as well as a statistical analysis of the impact of the type of introductory information on the engagement. Users seemed to find the introductory section adequate so they could understand the context as well as the nature of the exercise. This seems to be confirmed by a review of drawings carried out by participants from UCL without a design background, where 70% of drawings were of acceptable quality and had diagrammatic nature. Comments made by participants during the interviews made it clear that communicating site location and context was challenging, especially considering that the adopted Html canvas technology does not allow for zoom or moving through a map. Explaining the project situation needs to be developed via popups or other side information slides. Several test users were made to ensure participants related the small-scale canvas base drawing with the larger scale map including animated GIF images, which seemed to work best. However, this is likely to remain a challenge even after the experiment has finished.

We analyse the usage ratio of the tool across various groups outlined in the deployment schedule (see Usage Ratio column in figure 8). This helps us identify the impact of factors such as the nature of the introductory information and the forms of outreach. The web app was accessed a total of 4,928 times with a total of 481 valid entries. This gives around 10% overall tool usage. In general, it can be said that the web app was accessed shortly after the email campaigns were carried out, with most traffic being registered within two or three days after the mailing was carried out. Roughly 70% of usage happens during the first day with the remaining over the next couple of days. While this can seem low, it has to be considered that participants are not stakeholders from a strict point of view and, in most cases, there is no real benefit to their participation or engagement. Moreover, the tool only records an entry when feedback or the next step is requested, which could lead to many attempts not being recorded.

		Participant source	Webapp version	Intro	Briefing method	Design background	Entries	Drawings	Usage ratio	Total Actions	Average Actions	Av. lines quality	Av. buildings quality
Prototype	0	Arch-Phd	Double	slides - long	None	Yes							
1 (UCL)	1	Architecture students	Double	slides - long	None	Yes	193	34	0.18	451	10.91	0.70	0.62
	2	Civil Eng. 1st year	Double	slides - long	None	No	89	22	0.25	292	13.26	0.82	0.77
2 (UCL)	1	Health Sciences / Arch	Double	slides - long	None	No	330	19	0.06	197	13.27	0.66	0.94
	2	Physics	Double	video 30s	None	No	50	4	0.08	30	10.37	0.55	0.60
	3	All UCL (*)	Double	video 30s	None	No	356	36	0.10	559	7.50	0.71	0.35
	4	All UCL (*)	Double	video 25s	None	No	760	76	0.10	773	15.53	0.77	0.82
	5	All UCL (**)	Single	none	None	No	551	11	0.02	80	10.17	0.60	0.73
	6	All UCL (**)	Single	video 20s	None	No	532	15	0.03	170	7.27	0.62	0.49
3	1	Quora, Reddit, Linkedin	Single	video 25s	None	Yes	202	48	0.24	602	11.33	0.86	0.61
	2	Facebook, LAD	Single	none	None	Yes	318	32	0.10	303	12.54	0.78	0.68
	3	Linkedin	Single	video 20s	None	Yes	910	99	0.11	904	9.47	0.55	0.62
	4	Linkedin	Single	survey-long	UCL Survey	Yes	153	49	0.32	537	9.13	0.73	0.47
4	1	BigDraw + social media	Single	survey-long	UCL Survey	No	397	27	0.07	270	10.96	0.70	0.54
5	1	AA students	Single	survey-long	UCL Survey	Yes	48	5	0.10	49	10.00	0.63	0.41
6	1	AA students	Single	video 20s	None	Yes	39	4	0.10	32	9.80	0.90	0.21
TOTAL							4,928	481	0.10	5249	10.91		

(*) Includes members from Student Experience Panel
(**) Website active although not formal outreach mechanism was produced

Figure 8 Deployment schedule and results. Columns shaded to show higher values darker. Colours distinguish different columns for clarity

We can now look at Usage Ratios for different groups. The usage ratio of members of the SEP panel (UCL volunteers) matches the average of 10% while the usage ratio is slightly higher amongst professional groups. Some social media collectives are slightly above the average (Linkedin on 24% and Facebook on 11%). The results suggested that introductions of around 30 seconds would increase engagement, which would be lower in the case of having no introduction or longer ones (10-2 minutes). An exception to this rule was the user group from Linkedin, which had high usage of 34% after seeing the full website survey with UCL results and options. This can be because they are more likely to feel curious about the tool since some may see the research as relevant from a professional perspective and it is worth the effort of spending some time on it.

These initial results indicate that the exercise of diagrammatic sketching can be well understood by participants with no design background, especially when using a simple layout and a step-by-step narrative. Interviews indicated that people would understand what the problem was about and the drawings submitted seemed to confirm this fact. We also learnt that introductory information, while best kept short, can "hook" an engaged audience if it triggers their curiosity.

4.2 Analysis of user learning (research question 2)

While the previous analysis showed that users could understand the task they were asked to complete, this section shows how they also learned very basic aspects behind the problems of locating buildings and paths in a project. As previously mentioned, we will look at the evolution of drawing quality for lines and buildings both at an individual as well as an aggregate level.

Approximately 200 valid entries were developed for lines as well as buildings. However, the entries on building drawings were more successful than the line ones since users did more than twice the amount of attempts for building drawings (3.45 attempts) than for line drawings (1.68 attempts). Almost half of all users (49%) made several attempts at the building drawing while only 17% did so in the line exercise after requesting feedback. This seems to indicate that the building exercise proved to be either easier or that the feedback was more effective in producing an engaging response, therefore getting the participant to draw more.

While the number of tools uses is a good indicator of engagement, it is important to understand whether this is related to an improvement of the quality of the drawings or whether it relates to random trials and drawings. Figure 9 shows the sequence of all interventions indicating their qualitative evolution. We can see how the evolution of the quality of line drawings (right side) shows a certain tendency to improve, with some drawings getting closer to the upper limit. However, there is a substantial proportion of drawings that do not improve over time and remain of average quality or even reduce. This can be because the instruction about connectivity is not clear enough to elicit a clear response (ie there is no clear target or point to go to). In some other cases the drawing becomes worse over a short time to then improves towards the end, indicating that, rather than gradual corrections, the designer changed his/her mind and made a new attempt altogether.

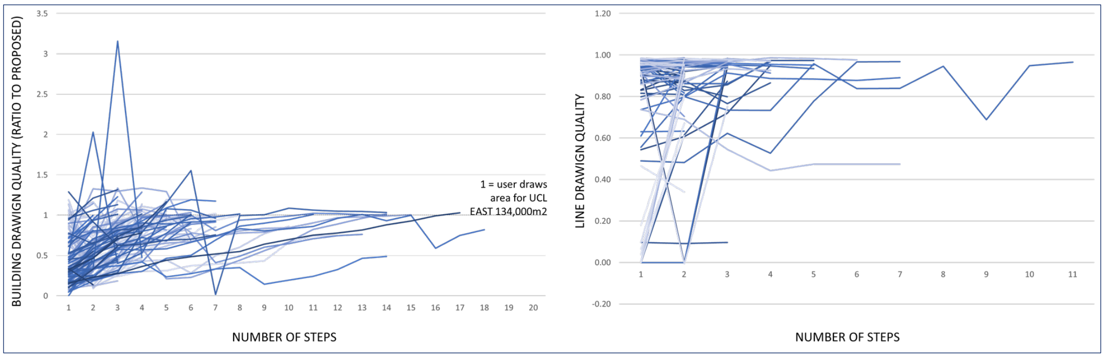

Figure 9 Evolution of line drawing quality

For building drawings (figure 9 right) the evolution seems to be more consistent towards an improvement, with a larger proportion of drawings tracing curves that tend to converge towards quality 1 (ie, users are likely to draw the correct quantity of drawings). This is likely to be because the objective is clear and easy to understand (add colour until reaching a level) and the method to reach this target is additive and gradual (ie the user does not need to start all over again).

Looking at the evolution of the drawings, a large proportion of drawings begin with a low amount of built area, with very few drawings coming down to the ideal. This can be because the overall quantity of development for UCL EAST (134,700m2) is relatively high as stated by several interviewees during the prototyping stage. This proposed built area translates into a drawing where the middle typology (pink plinth) almost covers the entire site. This seems to be intuitively a big step for the participant that is not likely to want to begin in such density. However, the evolution of drawing seems to show that people end up delivering the final quantity. Drawings that begin above the mark do not come down gradually. This can be because the drawing tools include an "undo" functionality, but not an eraser that can remove bits of fabric that have been drawn.

Figure 10 (left) shows an aggregate analysis of line quality for each user group shown in figure 8 compared with an average number of actions in each event (this number includes all actions including final feedback). It can be seen that there is a general tendency of improving drawings when the number of actions increases along the lines of what was identified in the previous analysis. This would suggest that the use of the tool helps people understand the nature of the exercise to a certain extent. A similar exercise is carried out in figure 10 (right) showing an aggregate analysis of building line quality. The scatter of the points shows a stronger correlation between usage and quality, indicating that the feedback provided by the interface had a stronger effect on drawing performance. This seems to reinforce the conclusions from the previous section and the idea that clarity of task makes participants try to "hit the target" and improve the drawing.

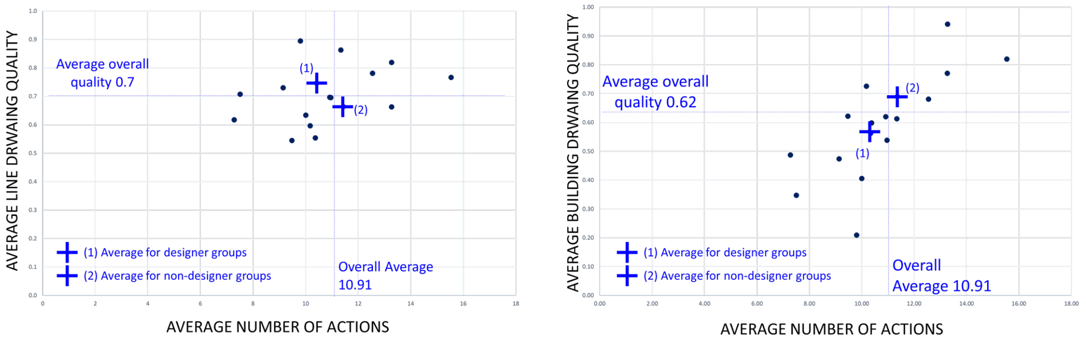

Figure 10 Average drawing quality per user group defined in Figure 8

4.3 Analysis of tool impact (research question 3)

As previously mentioned we develop a study of the main options that can be derived from the first stage of participation. We carry out PCA analysis for images of line drawings of UCL participants as shown in the centre of figure 11. The first three principal components of the line exercise show a strong perimetral structure (1st) and then a clear grid aligned to the edges and meeting the connection points on the East canal. We then complement this study with an analysis of the main connecting lines where for each drawing (left), we perform a graph extraction from the raster (see chapter 4) and obtain the 2 most direct connections (measured in angular change) between the entry points to the site as shown on the right side of figure 11.

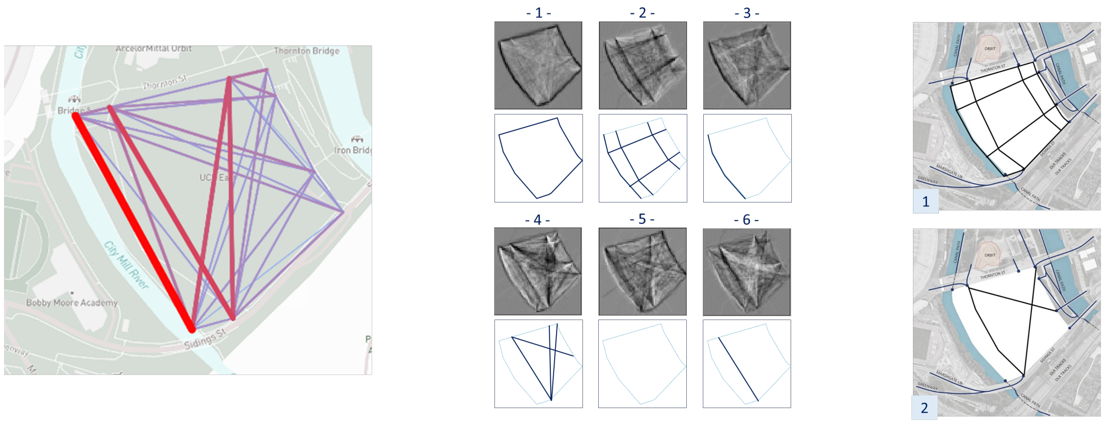

Figure 11 Option development for line drawing. Line aggregate (left) PCA analysis (centre) and options (right)

A similar exercise is carried out for the building exercise (figure 12) with aggregate building location (left) PCA (centre) and option development (right).

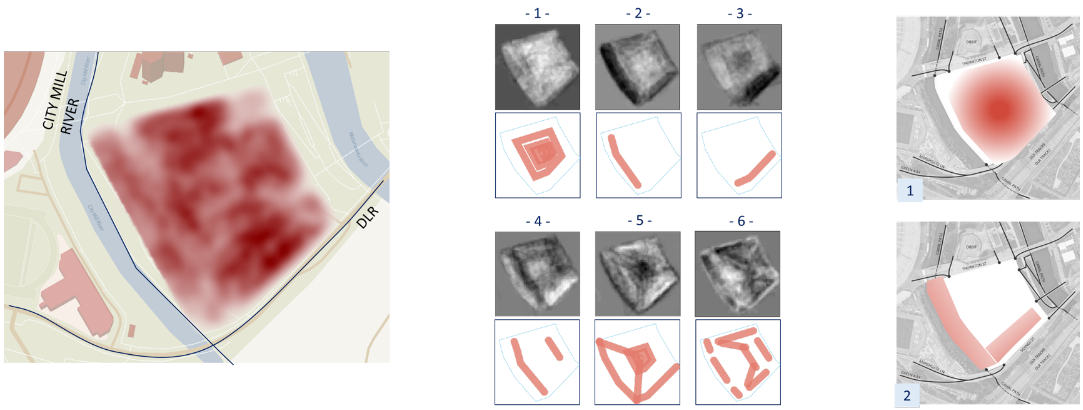

Figure 12 Option development for building drawing. Heatmap average (left) PCA analysis (centre) and options (right)

As previously mentioned, these are shown only to part of the design professionals, while another group of design professionals carry out the exercise as the general UCL members. This leaves us with three groups of users that can be compared, namely, UCL members, design professionals that have not seen the options and design professionals that have seen them. We gather data from three groups separately and develop three series of PCA analyses as well as aggregate analyses for the groups which are relevant to this last stage of the experiment. These three analyses are shown in figure 13 (aggregate analysis for line and building drawings), figure 14 (PCA for line drawings) and figure 15 (PCA for buildings drawings).

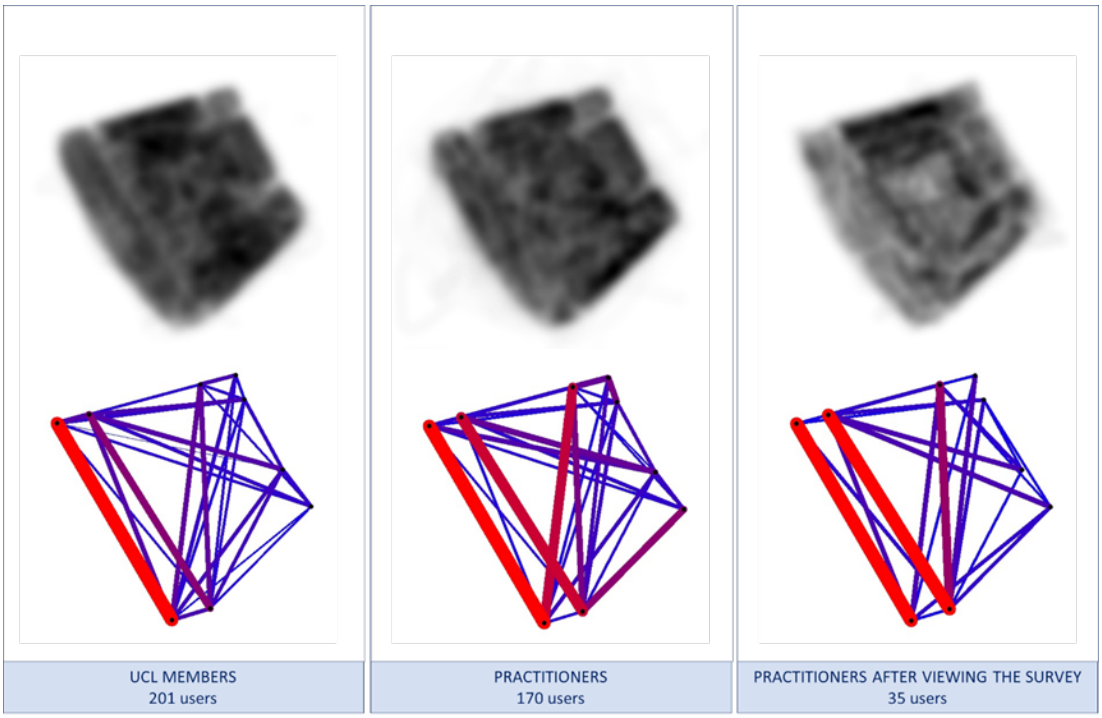

Figure 13 Comparative aggregate analysis of lines and buildings

Looking at the first two columns of figure 14 we can see how practitioners show a stronger use of diagonal crossing through the site which shows both in the first and second PCs. In the case of UCL members, these diagonals don't fully appear until the 3rd component, being most prevalent in the 6th. It seems that UCL participants have stuck slightly more to the grid implicit in the site following lines that are parallel to the edges and starting in the access nodes similar to what we extracted for Option 1. Designers on, the other hand, have worked diagonally, taking less consideration for the boundary lines. This would suggest that general members of the public have been more strongly compelled by the given site geometry (ie extracted the implicit grid) while trained designers have taken a more "free" view of it. The aggregate analysis (figure 13 shows a similar story, with a stronger prevalence of diagonals in the team of design professionals and a stronger parallel to the western canal for UCL participants.

In the building exercise (UCL members seem to have a strong preference for buildings along the west and south edges (2nd and 3rd PC) with practitioners treating the perimeter more equally and designing more toward the perimeter (2nd component). However, the aggregate analysis (figure 13 shows a similar structure in both cases, suggesting that the actual differences in PCs are relatively small.

In a second step, we try to see the extent to which the options extracted from UCL (first group in the left section of figure 14 and 15) have an impact on the PCs of the third column (designs by practitioners that have not seen the survey) shown in the right section of these figures. The top parts of figure 14 and 15 include a series of images and notes that explain the comparison of PCs. The left column shows the options extracted from the UCL that were shown to the practitioners in the third group. We then identify visually which of the PCs from the practitioner's group change before and after seeing the options and we extract those PCs where these changes are easy to read (upper part of the figure). We then trace on top of them what this change has been and assess whether these changes are similar to the options shown by the UCL user group. If there is a difference between PCs of the middle and right column and that difference is related to the options from the first column, this would suggest that the drawings carried out by the third group were influenced by the options. This principle should apply to both paths and building PCs.

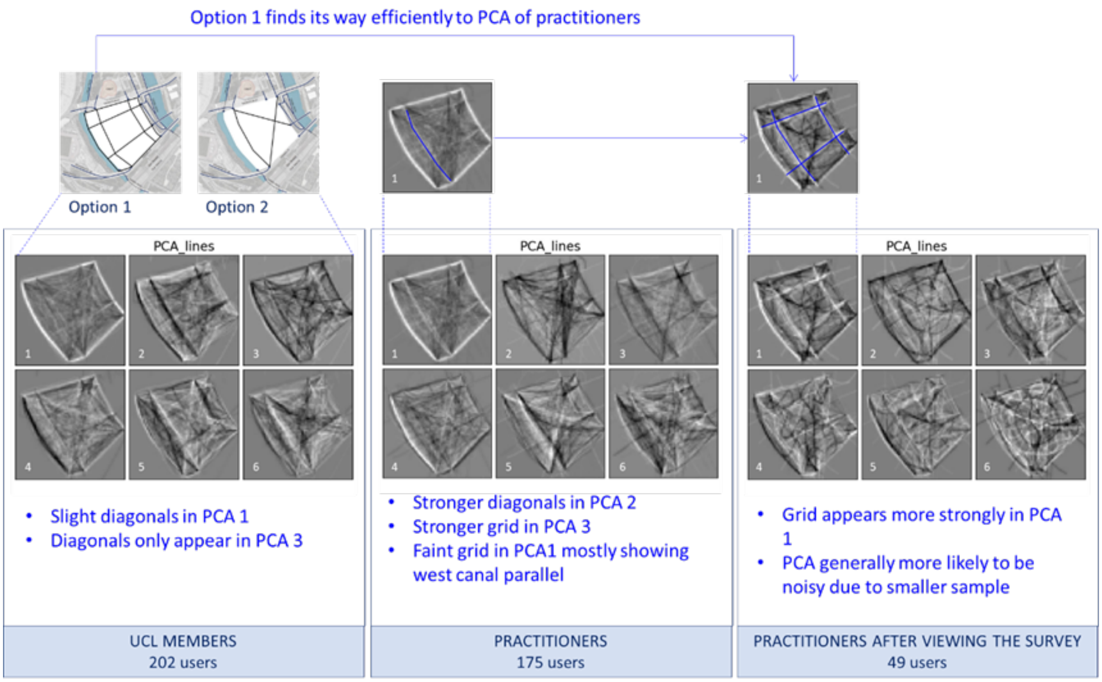

Figure 14 Comparative PCA analysis for line drawings

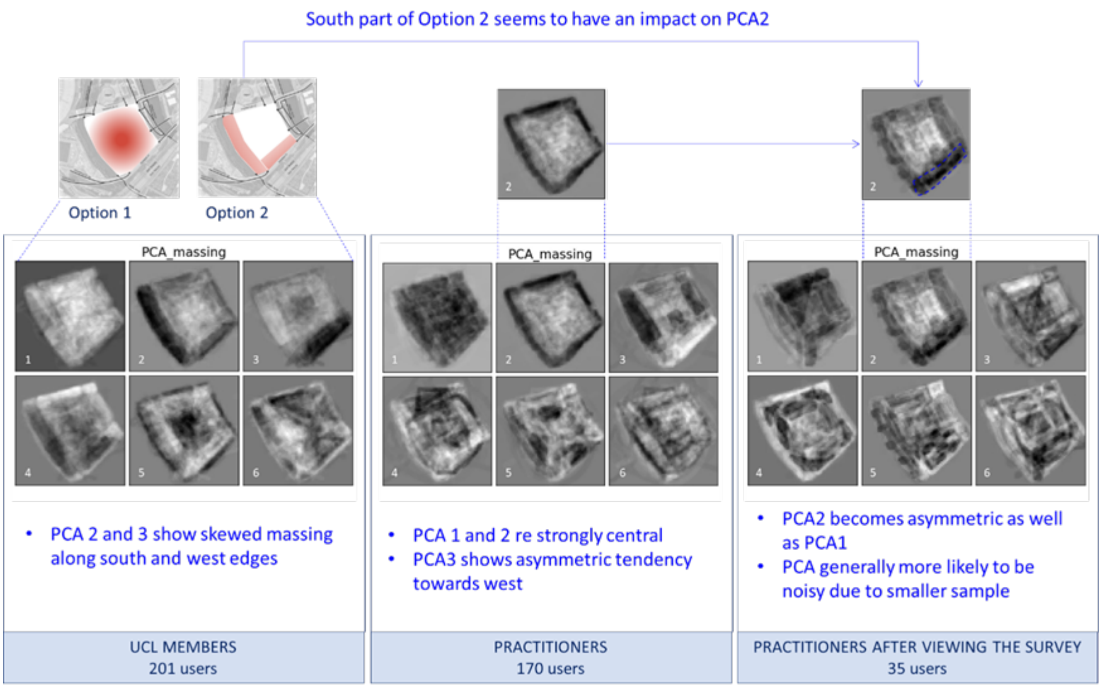

Figure 15 Comparative PCA analysis for building drawings

Looking at the line drawings (figure 14) PCs of the dataset corresponding to practitioners that have not seen the options would show a diagonal preference with a smaller grid preference.

However, after reviewing the survey and Options from UCL participants, the PCs of practitioners show a stronger grid preference with a parallel structure to the site boundary emerging from the first PC. This suggests that reviewing the option before carrying out the exercise has had some impact on the practitioners and that the options from UCL participants have left an imprint on the final production. We have also to consider that the tool usage was three times higher than the average (around 34% as opposed to 10%) indicating that this collective of users was much more interested on average than the rest of the users after reviewing the options. This would seem to indicate that this information was reviewed carefully before the user moved on to draw their proposal. Looking at the aggregate line analysis (figure 13 below) would confirm the above findings. The connection pattern of the third group shows a smaller influence of diagonal lines, which is to be expected due to the influence of the grid shown in Option 1 of UCL participants.

Looking at the building drawings (figure 15 we can see an initial tendency to draw perimetral structures by practitioners (PCs 1 and 2 from this group are central) while UCL members tended to compose using edge blocks South and East. However, there is not a marked difference in the overall aggregate drawings (figure 13). Comparing initial PCs it is hard to see the influence of the options in the building distribution of the practitioner's design after the survey.

Overall, there seems to be a tendency to indicate that options derived from general members of the public are considered in the work of design professionals. This indicates that this collective is likely to give credit to the aggregation of information coming from design-based surveys, hence, finding it relevant and meaningful.

5 CONCLUSIONS

A review of the results of this experiment indicates that sketching and diagramming are effective forms of letting the public express themselves efficiently and produce results that are interpretable and are considered valuable by designers. General members of the public are likely to draw lines that are easily transformable into graphs and further processed using SS theory, therefore opening up this field of research to that of DPPs. Moreover, architects and planners are likely to regard aggregate data gathered from crowdsourced design as a relevant form of input and are likely to be incorporated by professionals into their proposals.

Our research also highlighted key aspects of how to design the interface design and user experience of DPPs tools. We could see how long explanatory introductions may deter users from effectively engaging with the tool so it is better to get "straight to the job" with as little introduction as possible to then inform the user via popups and online indications as they get going with the drawing experience. However, this can be the opposite if we tap into an agenda or interest of the participant in the introductory information. Introductory websites with information that may appeal to a target group (professionally relevant, linked to hobbies or lifestyle) will have a positive effect and increase interest in the exercise. We also learnt that non-expert users are more likely to engage with design problems that are gradual, additive or allow for small changes to arrive at a clear target. Numeric or quantitative definitions of design problems can help, such as is the case with the total built area.

Further research could be carried out on the configurational analysis of the composite drawings, trying to understand the extent to which participant drawings score or rank in terms of their SS qualities, especially compared with proposals of practitioners. This type of research can take place working, not only at the individual site level but perhaps more across several sites that may need interconnection or larger pieces of urban fabric that need stitching together at a larger scale. Other lines of research can also try to use other forms of drawing tools that simplify lines, generating more streamlined drawings or even simpler “node-to-node” connections suggesting “desire lines” across sites.

In conclusion, SS theory and practice can benefit from enlarging the type of tools being used to reach out to potential users, opening the possibility of popularizing the ideas and approaches of this rich form of urban theory by the mere act of drafting lines on a white canvas.

REFERENCES

AGRAPH, n.d. AGRAPH, Software for Drawing and Calculating Space Syntax Graphs - PDF Free Download [WWW Document]. URL https://docplayer.net/34676040-Agraph-software-for-drawing-and-calculating-space-syntax-graphs.html (accessed 3.29.22).

Bentley, 2020. OpenCities Planner (CityPlanner) [WWW Document]. CityPlanner. URL https://cityplanneronline.com/site/ (accessed 2.24.21).

De Koning, R.E., Van Nes, A., Ye, Y., Roald, H.J., 2017. Strategies for integrated densification with urban qualities: XI SSS: 11th International Space Syntax Symposium 2017. Proceedings of the 11th International Space Syntax Symposium (SSS 2017) 56.1-56.17.

DeCodingSpaces, 2021. DeCodingSpaces Toolbox | Computational analysis and generation of STREET NETWORKS, PLOTS and BUILDINGS. URL https://toolbox.decodingspaces.net/ (accessed 12.19.21).

Depthmap, n.d. SpaceGroupUCL/Depthmap. Space Syntax Lab - UCL.

DepthmapX, n.d. Release depthmapX v0.8.0 · SpaceGroupUCL/depthmapX [WWW Document]. GitHub. URL https://github.com/SpaceGroupUCL/depthmapX/releases/tag/v0.8.0 (accessed 3.29.22).

ESRI-ArcGIS Urban, 2020. What’s new in ArcGIS Urban (June 2020). ArcGIS Blog. URL https://www.esri.com/arcgis-blog/products/urban/announcements/whats-new-in-urban-june-2020/ (accessed 3.5.21).

Falco, E., Kleinhans, R., 2018. Digital Participatory Platforms for Co-Production in Urban Development: A Systematic Review. International Journal of E-Planning Research 7, 52–79. https://doi.org/10.4018/IJEPR.2018070105

Goodspeed, R., 2016. Sketching and learning: A planning support system field study. Environ Plann B Plann Des 43, 444–463. https://doi.org/10.1177/0265813515614665

grasshopper3d, n.d. Grasshopper [WWW Document]. URL https://www.grasshopper3d.com/ (accessed 3.29.22).

Gün, A., Demir, Y., Pak, B., 2020. Urban design empowerment through ICT-based platforms in Europe. International Journal of Urban Sciences 24, 189–215. https://doi.org/10.1080/12265934.2019.1604250

Hillier, B., 1996. Space is the machine. Cambridge University Press.

Hillier, B., Hanson, J., 1984. The Social Logic of Space. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511597237

Jankowski, P., Czepkiewicz, M., Młodkowski, M., Zwoliński, Z., 2016. Geo-questionnaire: A Method and Tool for Public Preference Elicitation in Land Use Planning. Transactions in GIS 20, 903–924. https://doi.org/10.1111/tgis.12191

Kahila-Tani, M., Broberg, A., Kyttä, M., Tyger, T., 2016. Let the Citizens Map—Public Participation GIS as a Planning Support System in the Helsinki Master Plan Process. Planning Practice and Research 31, 195–214. https://doi.org/10.1080/02697459.2015.1104203

Karimi, K., 2018. Space syntax: consolidation and transformation of an urban research field. Journal of Urban Design 23, 1–4. https://doi.org/10.1080/13574809.2018.1403177

Karimi, K., 2012. A configurational approach to analytical urban design: 'Space syntax' methodology. Urban Design International 17. https://doi.org/10.1057/udi.2012.19

Karimi, K., Parham, E., 2012. An evidence informed approach to developing an adaptable regeneration programme for declining informal settlements [WWW Document]. In: Greene, M and Reyes, J and Castro, A, (eds.) Proceedings: Eighth International Space Syntax Symposium. Pontificia Universidad Católica de Chile: Santiago de Chile, Chile. (2012). URL http://www.sss8.cl/media/upload/paginas/seccion/8151_1.pdf (accessed 3.29.22).

Li, Y., Zhang, J., Yu, C., n.d. INTELLIGENT MULTI-OBJECTIVE OPTIMIZATION METHOD FOR COMPLEX BUILDING LAYOUT BASED ON PEDESTRIAN FLOW ORGANIZATION 10.

Lu, H., 2018. Evaluating Urban Design Ideas from Citizens from Crowdsourcing and Participatory Design, in: T. Fukuda, W. Huang, P. Janssen, K. Crolla, S. Alhadidi (Eds.), Learning, Adapting and Prototyping - Proceedings of the 23rd CAADRIA Conference - Volume 2, Tsinghua University, Beijing, China, 17-19 May 2018, Pp. 297-306. CUMINCAD.

Mueller, J., Asada, S., Tomarchio, L., 2020. Engaging the Crowd: Lessons for Outreach and Tool Design From a Creative Online Participatory Study. International Journal of E-Planning Research (IJEPR) 9, 66–79. https://doi.org/10.4018/IJEPR.2020040101.oa

Müller, J., 2021. Evaluation Methods for Citizen Design Science Studies: How Do Planners and Citizens Obtain Relevant Information from Map-Based E-Participation Tools? ISPRS International Journal of Geo-Information 10, 48. https://doi.org/10.3390/ijgi10020048

Müller, J., Lu, H., Chirkin, A., Klein, B., Schmitt, G., 2018. Citizen Design Science: A strategy for crowd-creative urban design. Cities 72, 181–188. https://doi.org/10.3929/ethz-b-000192742

Nielsen, J., 1993. Usability Engineering, First Printing edition. ed. Morgan Kaufmann, Amsterdam.

Nourian, C. by P., Groups, V., n.d. Space Syntax [WWW Document]. URL https://www.grasshopper3d.com/groups/group/show?groupUrl=space-syntax (accessed 3.29.22).

Pelzer, P., 2017. Usefulness of planning support systems: A conceptual framework and an empirical illustration. Transportation Research Part A: Policy and Practice 104, 84–95. https://doi.org/10.1016/j.tra.2016.06.019

Penn, A., Hillier, B., Banister, D., Xu, J., 1998. Configurational Modelling of Urban Movement Networks. Environ Plann B Plann Des 25, 59–84. https://doi.org/10.1068/b250059

qua-kit.ethz.ch, 2020. Quick Urban Analysis kit [WWW Document]. URL https://qua-kit.ethz.ch/ (accessed 2.28.21).

Schaffranek, R., 2013. SPACE SYNTAX FOR GENERATIVE DESIGN : On the application of a new tool 050. undefined.

Senbel, M., Church, S.P., 2011. Design Empowerment: The Limits of Accessible Visualization Media in Neighborhood Densification. Journal of Planning Education and Research 31, 423–437. https://doi.org/10.1177/0739456X11417830

sklearn, 2020. Faces dataset decompositions — scikit-learn 0.24.1 documentation [WWW Document]. URL https://scikit-learn.org/stable/auto_examples/decomposition/plot_faces_decomposition.html (accessed 4.28.21).

Space Syntax - Network, n.d. space syntax network [WWW Document]. URL https://www.spacesyntax.net/ (accessed 3.29.22).

SpaceChase [WWW Document], 2021. . Food4Rhino. URL https://www.food4rhino.com/en/app/spacechase (accessed 3.29.22).

SpiderWeb [WWW Document], 2011. . Food4Rhino. URL https://www.food4rhino.com/en/app/spiderweb (accessed 3.29.22).

SSL, n.d. Nur-Sultan Masterplan 2030 | Space Syntax [WWW Document]. URL https://spacesyntax.com/project/nur-sultan-masterplan-2030/ (accessed 3.29.22).

van Nes, A., Yamu, C., 2021. Space Syntax Applied in Urban Practice, in: van Nes, A., Yamu, C. (Eds.), Introduction to Space Syntax in Urban Studies. Springer International Publishing, Cham, pp. 213–237. https://doi.org/10.1007/978-3-030-59140-3_7

Zhang, L., Geertman, S., Hooimeijer, P., Lin, Y., 2019. The usefulness of a Web-based Participatory Planning Support System in Wuhan, China. Computers, Environment and Urban Systems 74, 208–217. https://doi.org/10.1016/j.compenvurbsys.2018.11.006