Space Syntax in Design Curriculum

Opportunities and Challenges

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Abstract: Space syntax is a prominent theory for understanding some key aspects of the built environment and people’s behaviour within it. Hence, familiarity with the theory would be an advantage for the designers to analyse, learn from and improve the exiting design as well as to create a more responsible built environment in future. However, the theory of space syntax has not yet been adequately integrated into the curriculum of many design schools. This paper presents an analysis of opportunities and challenges of the application of space syntax in the undergraduate architectural design curriculum. The goal of this paper is to anticipate these challenges and support a curriculum planning strategy for the matter. For this purpose, this paper first provides a brief review of previous studies and efforts to integrate space syntax into the design pedagogy. Then, it pursues a qualitative approach to identify different aspects of the relevance of space syntax within the design pedagogy. At the end, the paper presents our approach to address the considerations arisen in the literature review and introduces some of the steps planned for familiarising architectural design students at the University of South Australia.

Keywords: Space syntax; design pedagogy; design curriculum.

1. Introduction

Space syntax is a prominent theory of understanding some key aspects of the built environment and people’s behaviour within. The theory is based on the abstract formulisation of human’s visual and mobile behaviour by geographic and geometric information from the surroundings (Ostwald, 2011). Space syntax theory provides robust and reasonably objective arguments, methods and techniques to model and predict effects of architectural and urban design on important social issues related to privacy, safety, crime rates, prosperity, traffic control, etc. Familiarity with the theory and its implementation would be a significant advantage for the designers in analysing, learning from, and improving the exiting design as well as in creating evidence-based, responsible and, sustainable built environment in future.

However, the theory of space syntax, its findings and tools have not yet been adequately integrated into the curriculum of many design schools, especially at the undergraduate stage (Griffith, 2014). Familiarity with space syntax, especially its theoretical framework, may improve the students’ skill set when they enter the profession. This is particularly important for Australia as the county plans for important measure to boost construction of new housing and development of cities.
The present paper aims to provide suggestion to improve the role of space syntax in design pedagogy. This paper tries to address this goal in three further sections. First, it provides a brief history and description of space syntax. Then, it reviews the existing studies on the teaching or using of space syntax in design schools. Third, it identifies potentials and challenges towards incorporation of the space syntax in design pedagogy. Finally, it proposes a preliminary step taken to address some of the issues.

2. Space Syntax

Space syntax was initiated at University College London (UCL) in 1970s by Bill Hillier and colleagues (Hillier et al., 1976). Their studies culminated in Hillier and Hanson’s book, The Social Logic of Space (1984). In summary, the theory tries to translate the complex and concrete fabric of space into discrete and syntactic components whose relations are explicable by mathematical mechanisms. The mathematical context in discussion is the Graph Theory that processes the topology of things with graphs – a set of nodes which are interconnected with edges. In space syntax, the space (usually in the form of floor/street plan) was abstracted into nodes based on their geometrical properties. Initially, there were two basic ways of abstraction which can be roughly expressed as 1D straight lines (e.g., streets and paths, called axial lines) and 2D convex areas (e.g., rooms and plazas, called convex spaces). The edges of the graphs are usually defined as when the nodes have direct access to each other (e.g., openings between adjacent rooms or intersection between streets). Later, in 1990s, a third related geometric abstraction of space called isovists was merged into space syntax corpus (Turner and Penn, 1999). Isovists were first proposed by Benedikt (1979) as a polygon representing the area visible from a point. In the space syntax approach, the points, as defined by a grid articulation of the floor plan, are represented by the nodes of the graph and their mutual visibility determines their connection. The outcome of the abstraction is call a map (i.e., axial map, convex map and isovist map for the respective mappings, though the last one is also called a visibility grid). Each of the mappings have been furthered by variants such as social boundaries (Peponis and Wineman, 2002) instead of strictly convex areas, and segments (Turner, 2007) or intersections (Batty, 2004) of lines instead of whole axial lines. The focus of the mathematical calculations is on either the likelihood of components being accessed and visited or that of being passed through (Hillier and Hanson, 1984). The former type of measures is termed with words such as integration while the latter implies choice.

3. Existing Approaches to Applying Space Syntax in Design Curriculum

Space syntax has more than thirty years of being seriously approached in academia. However, the available publications on this subject are scarce. Of course, this does not mean that similarly few pedagogical approaches to space syntax. For example, Dalton and Vaughan (2008) report that space syntax was taught to master students at UCL for decades; however, their report is the only publication discussing that course. Griffith (2014) also considered “many” design schools implement space syntax in their courses. However, he also argues that the relationship between space syntax – as a theory and research area – and design is not well defined and explored. Hence, in this subsection, we present published records of incorporating space syntax within design courses:

- UCL Bartlett School of Architecture has probably the most comprehensive approach to teaching space syntax with a master’s degree dedicated to the theory (UCL, 2017). Presumably, this degree is similar to what Dalton and Vaughan (2008) reported (their report discussed a one-year postgraduate degree titled “Advanced Architectural Studies”. However, the current course with this title at UCL does not match the description in that report). The 2008 programme contained
three teaching approaches (called “practicum”) including, firstly, a technical workshop to study the techniques and tools by a case study (a house); secondly, a formal and theoretical lecture on theories directly related to the techniques; and finally, readings of different theories about space. The current programme at UCL is titled “MSc Space Syntax: Architecture and Cities” containing 180 credits of which 60 are the final dissertation. Regarding the courses in the programme, the three approaches in the 2008 report are traceable.

- Schneider et al. (2013) report a studio at Bauhaus University of Weimar, titled “Research-based design”. The studio was held during one semester in winter 2013 and only involved masters’ students. The goal of the studio was to understand “how far designs can be derived from evidence” (p. 3). Space syntax was selected as the main method to fulfil this goal. The first task of the studio was to make students familiar with the concept of orientation in the buildings (with Bauhaus building as the case where students were asked to personally navigate). Then, the students were introduced to theory and techniques of space syntax and asked to perform some measures on existing or algorithmically generated buildings. In the third step, design task was given to students and they were asked to use space syntax to evaluate and select their design alternatives. Further steps were taken to evaluate the designs (by also using VR), and a secondary task given to the students. To evaluate the success of the studio, the students were asked to fill out two questionnaires about both the studio and their current architecture education. While the students found some difficulties with the tasks, they were mostly clear about that the studio provided more scientific input to the design than their usual courses.

- Unlike the previous examples, Reveron (2009) focused on first-year undergraduate architecture students, at Universidad de los Andes in Merida, Venezuela. The students were divided between a control group and an experiment group while only the latter was taught about space syntax theory and techniques. Both groups were given a same design task to be articulated on a grid network. For assessing the results, the same task was given to a group of practicing architects. The study found that the experiment group designed more integrated buildings and performed closer to that of experienced architects.

- Griffith (2014) outlines some issues regarding teaching space syntax. First, he reiterates an earlier caution by Hillier that design courses should not focus only (or mainly) on the technical features of space syntax (techniques and tools) but firstly on the theoretical background of space syntax. This caution is regarding the overemphasis on the crude quantification which may negatively influence creativity of the design. Further in the article, Griffith answers two questions of what map and which measure should be used (or learned) by the designers. He prioritises axial maps with measures of integration and choice. Nevertheless, it is possible that the choice of axial maps is related to the implied urban focus of his book chapter.

The above reviews do not draw a complete picture of the inclusion of space syntax in design curricula. However, they provide us with a few noteworthy insights. First, while the theory and its techniques may be considered advance within the mainstream architectural pedagogy, even first-year students were able to understand the basics and successfully adopt it in their design. However, students may struggle with combining different aspects of the theory in more complex design tasks. In the next section, we try to identify some of these potential challenges.
4. Pedagogical Issues and Challenges

In this section, we discuss different aspects of space syntax which may affect the pedagogical application. We have identified four aspects of space syntax which may create challenges in its incorporation within design curricula. These aspects include those related to the general theory, techniques, tools and research findings. These aspects are discussed hereafter.

4.1 The General Theory

By the general theory, we mean the theoretical background behind the space syntax interpretation and abstraction of the human behaviour and built environment. It also includes basics of the measurements (such as a generic implication of the integration value, as noted in Section 2). In summary, the general theory is simple and would not possibly be difficult or time-consuming to teach to students even in a larger course on spatial theories. Reveron’s experiment (2009) has showed that even first-year students would grasp the basics of the theory. The more complicated side of the general theory is the critical debate around it and its limitation and implication. However, even in space syntax research, this side is not usually approached unless the research focuses on the philosophy of the theory. In addition, a basic understanding of graphs is required to have an acceptable grasp of that model.

4.2. The Techniques

The techniques of space syntax are probably the most difficult to cope with from a designer perspective. On the one hand, they are very abstract and mathematical in both what they represent and what they present. Indeed, Griffith (2014) considered questions about the techniques and measurements as frequently asked by designers. On the other hand, they have also numerous types and approaches. Currently, there are three types of maps (convex, axial, isovist or VGA) and several different approaches to utilising these maps (i.e. social and geometric boundaries in convex maps; primal, dual and segment axial maps; isovists, visibility grid and agent-based approaches to isovist maps). The analysis of each map would may include various possible measures (e.g., choice, integration and control value for convex maps). In addition, some purposeful analyses may require multiple approaches in the same analysis (e.g., convex maps with and without exterior, or axial maps with different radii).

Further difficulty may arise during and after the measurements. For example, some of the techniques require a number of parameters to be set beforehand. These parameters have certain nomenclature which may not be understood without a deeper knowledge of mathematics behind the measure (e.g., *radius* in axial map and VGA measures or *interval* in agent-based modelling). After the measurement, there are different ways by which the results are presented for each mapping type.

Clearly, learning all of the techniques and mastering their analysis will take an excessive time within a three- to four-year design program. We may argue that some design students may never need to master all of the techniques. For example, segment maps are only used in street maps for urban planning and design, not building interiors. In contrast, convex maps or VGA (except agent-based modelling) are not as common as axial maps in urban design analysis. However, even after such exclusions, the number of remaining techniques may still be too complex to be manageable in an undergraduate programme.
4.3. The Tools

Currently, depthMapX (Varoudis, 2015) is the only mainstream non-commercial software for space syntax analysis. DepthMapX (originally, DepthMap) provides an interface for drawing and measuring space syntax maps based on design documentation (mainly floor plans) which are imported as CAD drawings. The results are visualised by coloured maps on the plans or exported in spreadsheet files.

However, depthMapX was originally designed early 2000s and so does not feature a high level of interactivity expected by designers. Neither has it provided integration with CAD tools used by professional designers such as architects, without further scripting. It seems that the software was intended mainly for research not specifically for design purposes.

Another issue with depthMap which further reduces its integration or interactivity is its relatively slow speed. For example, for each small change in the design, the whole graph (axial or isovist maps) should be redrawn and recalculated from scratch. Particularly for VGA, each recalculation may take tens of minutes to hours. In convex maps, while the calculation is very quick, the manual redrawing of the map may take a considerable amount of time. There is also the possibility of losing the redrawn data because depthMap occasionally becomes unresponsive after minor changes to the convex or axial maps (based on the authors’ experiences).

4.4. Research Findings

There have been numerous research outlets regarding space syntax since its emergence in 1980s. The studies have usually approached space syntax in of the following two directions (Amini Behbahani, 2016):

- to seek for empirical support for space syntax measures or to investigate how a space syntax measure correlates with a real-world issue;
- to analyse a design – proposed or constructed – by space syntax techniques to understand its spatial configurations.

Often, these studies focus on a single issue with a single technique. For example, a study compares the level of attention paid by nurses to wards in a hospital with the integration value of wards and the triage station for the hospitals convex map (Haq and Luo, 2012). Once a correlation is found, subsequent studies will try to evaluate the performance of hospitals on this particular issue based on the correlations. Presumably, there will eventually be designers who use the first research findings or the guidelines coming from the latter studies to improve their hospital design.

In this regard, the main pedagogical issue is the efficient use of the specific context and findings of these research. To apply such findings in their design and learning, students and architects need to find the relevant publications, study them, contextualise the findings and extract guidelines. For each task, the students may need more than a rudimentary knowledge of the theory to go through the articles and understand numbers, keywords and limitations in the studies. Of course, this is only when there are specific studies available for the students’ design context.

5. Proposed Solutions

In this section, we try to identify or propose some solutions for the challenges mentioned in the last section. The solutions are discussed within two levels. First, we discuss general solutions addressing the
identified challenges, which may help with future implementation. Then, we introduce some practical steps which we have taken to address the issues in a recent architectural studio for third year students.

5.1. General Solutions

In the last section, major challenges were identified in three of the four discussed aspects of space syntax for design students. In summary, the major issues were that the space syntax techniques are numerous and may be confusing; the tools are mainly suitable for research not design; and the findings can be very specifics and scattered in the literature. In this subsection, we propose some general solutions to address these challenges.

The findings of space syntax studies often inform designers and policy makers to take necessary actions to improve design. In this sense, they resemble guidelines and standards although such findings are limited to certain scopes and contexts and are subject to further critical limitations. Once designers decide to apply such findings they may treat them similar to other standards and guidelines. Designers are usually familiar with documentations of standards and guidelines. Documentation approach may be useful to facilitate designers’ access to the space syntax findings. This documentation can be in the form of an open web database containing the relevant and regularly updated information. This database can be collectively contributed and maintained by space syntax researchers and practitioners.

Another issue with many space syntax tools is that they are not integrated properly into design process because of the lack of interactivity in the tools and the potentially long duration when performing measurements. There are already studies that aim to address this issue. There are simpler, faster and more user-friendly tools emerged such as Agraph(Manum et al., 2005) and Viraph(Amini Behbahani et al., 2016). However, none of them has the inclusiveness of depthMap regarding the techniques. There are also studies with focuses on using space syntax within CAD programs like using convex maps in Rhino(Herthogs et al., 2013).

The above solutions may reduce the effort for students to understand and apply space syntax. Hence, they may have more time to them to focus on learning the analytical techniques. Furthermore, to avoid overwhelming the students by the complexity of the techniques, it is possible to only include simplified but fundamental techniques in relevant foundation courses beforehand. For example, convex maps are similar to bubble diagrams which are often used by designers to represent programmatic features of the design. Hence, by asking the students to redraw the diagrams with different focuses relevant to space syntax, the students are made familiar with the core concept of graph justification in convex maps. With such foundation courses, the main features of the techniques will be more efficiently mastered by the students because the conceptual understanding is established in advance.

In summary, there are three propositions in our approach listed below. Figure 1 shows a schematic diagram of these propositions within design program:

- an open web database containing the research findings and details design applications;
- more interactivity and faster analysis in tools to be better integrated into design process;
- foundation courses to teach conceptual bases of some space syntax techniques in advance.
5.2. Practical Steps planned for a third-year Architectural Studio

The previous subsection outlined three propositions to address the teaching of space syntax to design students. However, to implement them, a comprehensive plan is necessary which will also require some advancements in CAD tools. Until such a plan is mature and becomes practical, design students may still find it challenging to apply space syntax in design and learning. We have tried to devise a plan with practical steps with architecture students. This plan was implemented for the third-year architecture students at the University of South Australia.

The first step was to optimally use the available material. For example, we used the latest depthMap tutorial (Pinelo & Turner, 2010) and a few basic and concise summaries articles about space syntax as the core learning resources. These included a Brief introduction by Bafna (2003), Spatial structure of environment and behaviour (Peponis and Wineman, 2002) and a chapter from the first author’s thesis (Amini Behbahani, 2016). To facilitate the learning of the students, further explanations and examples were added to the depthMap tutorial to show the implications of the techniques explained in that tutorial. In addition, a concise set of slides were prepared to highlight the use of these techniques for design by existing examples. Together, they would help to contextualise these resources for the students learning.

The course only focused on using depthMapX software because it is important to learn this mainstream tool. The students were then instructed how to maximise the efficiency of working back and forth between depthMapX and CAD tools such as Autodesk Revit (the students were allowed to choose different CAD tools).

Similar to the previous studies, a design task was assigned to the students including the redesign of a number of historic hotels (pubs) in Adelaide including the Austral, Botanic, Black Bull and Stag hotels. The students were instructed to redesign these hotels to meet present standards and lifestyles with the help of space syntax analysis. A small database of selected research findings of space syntax was also prepared in the light of the first proposition. A list of space syntax findings was made available to the students as a
reference for various space syntax techniques and their usage. However, it was expected that students would only use generic space syntax findings because there is almost no space syntax study specifically on the topic of hotel buildings. Figure 2 shows a sample (redesign of New Market Hotel, Adelaide) given to the students on how to use the space syntax measures in their project. A set of slides explained for them how the measures justify the proposed changes in the plan.

Figure 2. A guide for using space syntax in the design task given to the students. Rows: existing ground floor plan of New Market pub (top) and a proposed modified plan (bottom). Columns, from left to right: raw floor plan, convex-map integration, angular mean depth, and connectivity (VGA).

While a thorough analysis of the plan and its outcome is outside this paper’s scope, some observations are provided here. regarding results and responses from the third-year students of Bachelor of Architectural Studies. The main observations from the students’ analysis included how fascinated they were that this method we were proposing would give them design insight. The student cohort seemed a little reticent to embrace it at first as they had been working at the beginning of the semester with analogue methods of measured drawings. They were initially confused as to the value of working between the digital and analogue. We explained that this was an evidence gathering exercise where spatial syntax offered a computational analysis for them to first interrogate the existing spaces of the historic pubs. The students engaged with the software to ascertain visibility and connection of the plan forms.

Students’ reported that spatial syntax prompted decisions about “where to start the design process,” “areas of the plan to focus on for greater visibility” and “points to intervene with their new extension.” They felt it was a “valuable” and “interesting tool” with which they would have preferred more time to experiment during the studio.
Some of the students represented the spatial syntax diagrams using a three-dimensional layering on clear Perspex. This was very effective in understanding the results across the volume of the building. They also expressed how they were able to understand the two-dimensional analysis and effects beyond each floor. Other students presented the “as existing” analysis adjacent to their “design concept floors” and talked to the method which informed their design decision-making. “Visibility and connection” for the new extension was vital to the way they organised their new spaces irrespective of the diverse programs which were selected across the four pubs under study. The adoption of the two quite distinct methods for this studio, without presenting the students with a preference for either, meant they became skilled in two approaches. It also gave them the confidence to compare each approach through a data collection, evidence gathering process which offered a unique set of parameters and experiences from which the students could expand their thinking around design processes.

6. Conclusion

This paper has outlined a number of challenges against the inclusion of space syntax in the design courses. The challenges include the complexity of the techniques, lack of interactivity of the tools and sparsity of the research findings. The paper has proposed respective solutions for these challenges although these solutions may vary depending on the context of the course and the intended purpose of the instructions.

The paper further discussed a plan for teaching space syntax in an architectural design studio to third-year students. The outcome of the studio is yet to be fully analysed, however, the interaction with the students and our observation of the outcomes suggest a satisfactory interest and familiarisation of the students with the topic, and their ability to introduce space syntax analysis in their design decision making. The future research will include a thorough evaluation of the studio and further development and verification of the propositions.

References


Varoudis, T. (2015) depthmapX is a Multi-platform spatial network analysis software, ed.