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Syntax as an Iterative Architectural Design Tool

A teaching experiment using spatial syntactic and isovist analysis

FREYAAN ANKLESARIA[1] & SAM MC ELHINNEY[2]

[1]INDEPENDENT RESEARCHER, AHMEDABAD, INDIA

[2]UNIVERISTY OF CREATIVE ARTS, CANTERBURY, UK

ABSTRACT

While space syntax has developed significant explanatory capabilities in the realm of the space-society relationship, its direct applicability within design is relatively nascent. Cases of application at the building scale are comparatively few. In our paper we describe one such instance, an undergraduate architectural design studio at CEPT University in India, which explored the application of scientific methods within creative and speculative design processes. This paper describes the design methods developed through this studio. The process was semi structured, adjusting as the course progressed, in order to incorporate emerging methods.

We propose that analytic tools which provide the precision and accuracy required by researchers are less conducive to the iterative process of design; instead, the capability to test out design ideas roughly but quickly serves the design process better. In this studio course we introduced the theories and methods of space syntax alongside two software tools that enabled both such approaches; DepthmapX, and the isovists.org app. The forms of analysis used in the studio included convex permeability maps, their justified graphs and network centralities; point and path isovists' local metrics; visibility graph analysis for global measures of visibility. The briefed aim of the studio was to use such tools as an approach to the design of a school building.

We find that successful processes emerged when students used the tools in a rapid yet rigorous iterative process of testing, modifying and re-testing. For most part, contrary to a generative design process, the designer's intuitions and subjective speculations actively interacted with the objective analysis to arrive at design decisions. Finally, we describe the pedagogical influence of introducing objective methods in a design studio which is conventionally a space of creative or subjective processes.

KEYWORDS

Space Syntax in architecture, architectural design methods, spatial analysis in design, design pedagogy

1 INTRODUCTION

1.1 The gap and the proposed bridge

In both academic research and commercial consultation contexts, the more prevalent scale of application of space syntax is urban. Such application largely reflects the assumed explanatory capabilities of the field in the realm of the space-society relationship, and perhaps also reflects more significant research funding and infrastructures. Cases of application of the field at the building scale are comparatively fewer in number. In the context of taught architectural design studios there are more limited examples, mostly recent, of which even less are documented and published (Krenz, et al., 2017).

The challenges in applying space syntax forms of analysis to design are manifold. There is a gap in the development of theory within space syntax itself; only some initial concepts dealt with the generative possibilities of spatial configurational systems such as the beady-ring process or 'restrictions on a random process' (Hillier, et al., 1984 pp. 59-62). Beyond such concepts the field has been predominantly focused on research and explanatory capacities (Psarra, 2013). From this follows a gap in the development of methodologies of application in design terms and, correspondingly, the tools and techniques for such application.

It can be argued, albeit assumptively, researchers generally prefer exact analytic data, and are happy to wait a while for it, given that a typical building plan may only need to be assessed once or twice during a study. Conversely, we can propose that designers regularly work intuitively and speculatively, with partial and editable information. As such, they are content with less accurate analytic data, but tend to consider it in a more detailed manner, producing numerous iterative analyses as plans are edited. The latter means that designers, unlike researchers, are less willing to wait for an analytic result.

Since Space Syntax tools emerged from research cultures, it is unsurprising that most provide the first form of analysis (slow and exact) rather than the second (rapid and estimated). A further elaboration of the relationship of speed to accuracy of results is presented in section 3.5 on methods and tools. In the undergraduate taught architectural design studio course described, we introduced software that accommodates both approaches; DepthmapX, and the isovists.org app. The contrast between the two provides the terms of our first key line of enquiry, i.e. the consideration of whether the assumptions outlined above are accurate and hold import for the design of both pedagogies and future tool sets. Previously too, researchers attempting the

application of space syntax methods in the design process have expressed a similar need "The shift of space syntax into a more generative role demands a set of conceptual and technical adjustments, including an emphasis on graphic language and visualisation and the necessity of fast feedback and interaction" (Miranda, 2013).

Our second line of enquiry addresses another assumed significant challenge, namely the assumption that the scientific objectivity of space syntax tools, and the absoluteness of their 'results' is itself limiting (by impression) to the creativity expected within a design process. About this unsuitability of the theory of configurational analysis within the subjective domain of architectural imagination, Bafna writes '…theory of imaginative function of architecture cannot be an extension of the theory of configurations because the imaginative function of architecture depends not on actual form, but instead on the phenomenal form of buildings' (Bafna, 2012).This challenge of bringing together the scientific and the creative in teaching is corroborated by assertions such as "...is analytical, evidence-based design teachable? and if yes, how could that be achieved?" (Karimi, 2019). We posit that such an impression of limitation itself restricts the adoption of such methods of analysis within design courses. We consider and test how to resolve such a conundrum by designing a course that uses space syntax methods of analysis for creative speculation rather than deterministic prediction.

1.2 Research Questions:

In our paper we therefore describe how, in an undergraduate architectural design studio at CEPT University in India, we explored the incorporation of scientific methods into creative and speculative design processes. The core questions explored through doing so are as follows:

- How did the use of space syntax methods influence the design process, but also, how did employing these analytic methods in design expand the possibilities of interpretation of the methods themselves?
- What is the observed pedagogical influence of introducing an analytic method like space syntax in a creative process?

1.3 The process and Inferences

In the CEPT studio, undergraduate students were taught the theories and methods of space syntax and were expected to use them as their approach to the design of a school in Ahmedabad, India. Student designers defined their own social programme for their project and used the analytic tools introduced to create spatial configurations that they considered best suited for their social intentions. In doing so they interpreted the analytic tools and created methods to employ these in design terms as the studio progressed. A summary of these methods are described in Chapter 4. We find that successful processes emerged when students used the tools in a rapid yet rigorous iterative process of testing, modifying and re-testing. The iterative process involved repeated cycles (averaging around ten cycles on key design decisions) of modification and analysis. Besides the number of cycles of design refinement through iteration, the thoroughness of the

process may also be said to lie in the number of ways (and corresponding methods and measures) by which each design-intent's translation into 'actuality' was tested. Designers repeatedly tested how well their designs were achieving the stated social intentions applying theories from space syntax to read multiple forms of analysis (convex maps, VGA, isovists, isovist path analysis) and using (albeit with their subjective interpretation) multiple spatial metrics within each analysis.

For the most part, contrary to the norms of a generative design process, the designer's intuitions and subjective speculations were actively interacting with the objective analysis to arrive at design decisions. Deviations from this approach are discussed as a limitation of the method. On examining the pedagogical influence of introducing objective methods in a design studio (conventionally a space of creative and or subjective processes) we saw a few notable effects. The objectivity of the analysis gave students confidence in the appropriateness of their designs. We observed a heightened sense of ownership of the design process, as students came up with their own individual interpretations and applications of the tools. Both the above findings inverted the dynamic of authority in the conventional teacher-student relationship. The student designer, having rigorously tested and examined numerous iterations of the design and researched the specific socio-spatial parameters of their interest, was often more aware of the basis of their design decisions and consequences than the tutor. Our concluding chapter elaborates on the pedagogical import of these findings.

2 THEORY

The foundation of ecological psychology, that the environment affords certain kinds of behaviors (Gibson, 1979) theoretically anchors attempts to use design to intervene in the environment-behavior relationship. Yet architectural theory has made insufficient progress in incorporating knowledge from the social and behavioural sciences (Sommer 1969, Lang 1987, Till 2009). By introducing the visual field - the 'Isovist', Benedikt made the first methodological advancement towards the perceptual and behavioural study of architecture (Benedikt, 1979). 'The social logic of Space' (Hillier & Hanson, 1984) offers a shift from the notion of space and society as distinct entities, by suggesting that they are inseparable; spatial configuration encoding social structure.

Space Syntax, developed by Hillier and colleagues at UCL, constitutes a body of theory and methods by which to quantitatively describe, analyse and explain the space-society relationship. It has developed as a science and knowledge base, establishing statistical correlations between spatial parameters and social patterns, to explain various urban socio-spatial phenomena in economics, crime, politics, etc. (Yamu, et al., 2021). Such work has found application in consultancy by Space Syntax Limited and others; Woods Bagot's Superspace (now ERA), Fosters and Partners etc. However, said application is predominantly urban in scale; examples of application at building scale are fewer. There is little academic research into, or development of, design methodologies which embed such knowledge in creative processes (Psarra, 2013).

Speaking about the experience of teaching analysis based urban design Karimi says “The most complex part of this process still remains the conundrum that whether analysis and research can generate design ideas, or not. Based on the outcome of student projects, it can be confidently claimed that at least in some cases, the analytical process itself generated the core design ideas.” (Karimi, 2019).

Dursun describes some of the initial and pivotal examples of the use of space syntax methods within the design process in academia and professional consultancy projects (Dursun, 2007). Further in this section we refer to a wide range of examples of application of space syntax methods in architectural design, exploring their contribution to the development of the said application.

2.1 Academia, research and professional practice

Space Syntax is being introduced within architectural and urban design studies at undergraduate and postgraduate levels in universities such as UCL (UK), ETH (Switzerland), DELFT (Netherlands), HVL (Norway), and beyond. The process of teaching these methods to students without prior analytic knowledge at BSc. and MSc.level is well documented (Van Ness, 2019). There are similarities and differences in the challenges faced while teaching these methods in the context of a design studio and with a focus on building scale. ‘Space Syntax Methodology and Analytic Design’ (Karimi, 2019) and ‘E-merging design research’ (Krenz, et al., 2017), are taught-modules at UCL, applying Space Syntax in design. The former is urban and strategic (in nature of intervention) and the latter intervenes at the intersection of urban and architectural scale. A notable teaching experiment titled ‘Design by research’ was conducted at the Bauhaus University in Weimar 2012-13, it used space syntax within the design studio process and brought together architects, spatial cognition and environmental psychology researchers and computer scientists (Schneider, et al., 2013). Similarly a studio at the Dept. of Architecture at the University of Thessaly, Greece in 2015-17 ‘‘….tried to introduce to the students a process of research-based design which is able to lead to generative principles” (Trova, 2019).

Some on-going research expounds the generative capabilities of space syntax methods, i.e. the ability to produce designs using configurational attributes as parameters in a parametric design process. Attempts at using space syntax methods generatively have often called for the modification of existing software or the development of new tools and algorithms (Miranda et al., 2013). Efforts to bring isovist and space syntax measures into parametric workflows include ‘Decoding Spaces toolbox’ (by Reinhard Koenig) and ‘Syntactic’ (Nourian, et al., 2013). These algorithms generate designs autonomously, limiting or removing altogether the designer’s active participation in the process of creation. Such developments are therefore different from the ones intended by our study, where designers are informed by analysis, but make design decisions actively by themselves also.

Within professional consultancy, the use of space syntax in design is being prominently practiced by Space Syntax limited, SpaceLab and ERA and Woods Bagot among others. The documented

and published aspects of their methodologies were referred to in the development of the studio course described here, albeit not deliberately replicated. While these examples do exist, we argue that the integration of such methods as actual generators of design, (rather than means for post occupancy analysis based interventions in an existing fabric), needs to be addressed and explored. The lack of such processes is captured in Karimi's quest " ….to link meaningfully the spatial and functional aspects of design through an analytical approach that is imbedded in the design process, not an add-on layer" (Karimi, 2019).

The work of Thomas Arnold provides some explorations of the latter. In his design process he uses axial lines to derive plan forms, in what he calls 'an architecture of visual relations' (Arnold, 2011). Such a process uses configurational attributes and the visual relationships they afford as direct tools of design thinking. We expand upon such thinking in our studio activities.

3 THEORY

3.1 The context and outline

The architectural design studio taken as the case study for this paper was a semester-long course taught at the CEPT University, Faculty of Architecture, in India. The course was formulated with the pre-expressed intention of using space syntax and isovist analysis as the basis for a design studio. It explored the application of scientific methods into creative and speculative design processes. Given the legacy of its founder and 2018 Pritzker prize winner Doshi, the CEPT Faculty of Architecture has traditionally maintained tremendous emphasis on the intuitive and artistic/creative impulse. Proposing empirical analysis as the basis for design was therefore a challenging novel territory to venture into.

The studio was formulated and taught by Freyaan Anklesaria, Catherine Desai and Abhishek Thakai (teaching associate). Anklesaria has studied Space Syntax at postgraduate level while others were introduced to it through literature as well as lectures and workshops on the software tools by Anklesaria and McElhinney. Fifteen second and third year, undergraduate, architecture and urban design students took and completed the course. All of the students were previously unfamiliar with the theory, methods and techniques of analysis associated with space syntax.

The course was sixteen weeks long with two major points of assessment of studio work at the mid semester and end-semester reviews. Being the module with maximum credits, students dedicated 35 hours a week to it. Due to the pandemic Covid-19 the studio was conducted online, with all lectures, workshops, design discussions, crits, presentations and reviews done over video conferencing. To some degree such circumstances allowed an expanded degree of expert engagement, with individuals from the Space Syntax lab at UCL (Prof. Sophia Psarra, Dr. Petros Koutsolampros and Ahmed Tarek Zaky Fouad and Aabid Raheem) critiquing student work at the review stages.

3.2 Pedagogical model - Semi structured approach

The course was planned as a structured design studio having a set of learning objectives, outcomes, a brief, a schedule of design exercises and a reading list. Initial steps were initially relatively clearly planned up to the point where an overall configuration of the spatial units was expected. From this

point onwards students discovered and explored ideas and methods specific to their design concepts and intentions.
ith few exemplar approaches to refer to, challenges in implementation of both phases were encountered, and the pre-defined structure of delivery was necessarily adjusted to overcome these. The structure may therefore be called a semi-structured approach to a generalised course framework. Such flexibility allowed a feedback loop to exist, identifying and accentuating potential new approaches to applying the analytic methods to the on-going design challenge as such approaches emerged.
There was a necessary process of reorientation for the student designers to think of design analytically rather than creatively at the outset. The readings played a key role in this process besides serving as direct reference material from which to learn the theories, methods, tools and techniques. Students were assigned weekly readings on the following topics: Space syntax, Isovistics, the design of school buildings, pedagogy and space.

3.3 The design brief

We chose the challenge of a school complex as a design brief for the studio for several reasons. Firstly, in terms of suitability for an architectural studio testing evidence based design techniques, schools offer sufficient complexity in terms of number of spatial units, repetition and scale to apply spatial analysis. Secondly, schools are a building type for which distinct developments in architectural typology can be correlated with changing pedagogical and social intentions, especially between the late nineteenth and late twentieth centuries. Such developments provided for a set of intriguing precedents that could be analysed using the tools of space syntax. Our assumption was that from such study students would draw observations regarding spatial organisation and social relationships, before later beginning the process of design. Finally, the Indian Government is currently implementing new guidelines for education which propose changes to long established pedagogy, making an investigation into the relationship between spatial organisation and social possibilities in schools one with potential for future application in the real world.

In terms of a detailed brief, students were asked to design a school with either 12 or 24 classrooms on a site in Ahmedabad, India. The age range of students was not specified and proposals included K2 - Grade 12 schools as well as dedicated primary, nursery and senior schools. The areas and functions were loosely based on the Indian CBSE (Central Board for Secondary Education) framework. The projects were to be developed in two parts, the first relating to pedagogy and the second to architecture. Each student was initially asked to propose an intended pedagogy and ‘social brief’ for their project. They then developed a series of designs in response to these pedagogical and social ambitions using an iterative process of analysis, reflection and adaptation.

3.4 Theories and concepts applied in design

A suite of basic concepts of space syntax and isovists were introduced to the studio learning process. The idea of spatial network centralities and their social relevance was explained using analysed

convex maps of familiar buildings and references from literature. The concept of the generic function (Hillier, 1996 p. 223) of buildings was used to introduce functionality and 'intelligibility', also making a broad classification between the functions of 'movement' and 'occupation' (Hillier, 1996 pp. 5-6). Concepts and measures of depth and centrality were taught as correlated with the social potentials they create. Integration and Choice as measures of spatial network centrality were explained to suggest to-movement and through-movement, thereby helping to gauge whether a space tended to be a destination or an on the way space. Finally, the representative forms of visual fields (including of isovists and visibility graphs) and their relevance to visual perception and spatial navigation were introduced as a medium for review and discourse of many of these core concepts.

Further theoretical frameworks introduced included that of socio-spatial organisational Correspondence and non-correspondence models (Hillier, et al., 1984 pp. 140-142), Topological space types (Hillier, 1996 pp. 245-249) and topological system types (Hillier, 2019) with their corresponding movement potentials, Conservative vs. generative systems (Hillier, 1996 pp. 196-201), deep vs. shallow integration cores (Hillier, 1996 pp. 125, 126, 130, 155, 187, 199, 263).

As the students designed their school buildings, they sought out concepts which connect space syntax with the design of spaces for learning and socialisation. Research connecting pedagogy/ teaching and learning behaviors (Zaky, et al., 2017) and office culture (Sailer, et al., 2019) to spatial parameters were particularly useful in grounding their thinking here.

3.5 Methods and tools

The methods of analysis used in the studio were of three broad categories: permeability analysis based on convex maps, visibility analysis based on isovists and visibility graphs. Convex maps were created and analysed using DepthmapX while visibility analysis was predominantly on isovists_app with very few cases of using the visibility graph analysis in DepthmapX. The graphs of the permeability structure were created using graphcommons.com and justified manually from various root spaces.

Within convex map analysis, the metrics examined were integration, choice, control and step depth. For the case studies, result data was also tabulated to examine the mean deviations of these metrics of a functional space type across all cases. During the process of design, these metrics were typically visualised on floor plans. For buildings with multiple floors, staircases were considered to add travel cost of one topological step.

The isovist analysis of the studio focussed on point isovists and local measures, typically full (360 degree) isovists examining parameters such as area (connectivity), compactness, vista length(max-radial), occlusivity, drift, min radial (Sailer, et al., 2019) (Benedikt, et al., 2019). Global measures of visibility, visualised in field form, were also analysed using the isovist_app, including angular depth, visual integration and control (semi-local) (Sailer, et al., 2019). Path isovist analysis (Dalton, et al., 2001) was also used; wherein one views the root space, the isovist within it and a trend-line (graph) of

selected metrics that identify how the visual experience of an imagined person moving along the path may change.

Isovists_app works with a method of successive stochastic isovist generation, interrelationships of these isovists are then tested, thereby circumventing the complexity of the dense VGA graph. This allows for speeds where one can see the precision of the results re-adjusting themselves in real time as one modifies the plan. On the point of the relationship of speed to accuracy, it should be noted that the isovist_app refines its results over multiple cycles, beginning with a low-accuracy (relative to its final result) which is seen immediately and subsequently keeps getting further refined for accuracy. The Isovist_app software's high resolution results, provided at unmatched speeds, were a key feature which the studio processes relied on heavily. These capabilities specifically enabled the process of repeated rigorous iteration.

3.6 The process

The studio course began with lectures and workshops teaching concepts, theory, methods and tools of space syntax relevant at the scale of buildings. By means of an exercise to create convex maps and graphs for the students' own homes, students were oriented to think of space configurationally as opposed to morphologically (as in their previous architectural training).
Fifteen case study school buildings were studied by the students, employing the methods of spatial analysis they had learned. Case study candidates were carefully selected to ensure that in each case it was possible to identify a clear social or pedagogical model intended by the architects or the management of the school. The cases represented varied architectural solutions for these pedagogical models . They dated from the late nineteenth to early twenty-first centuries and included Herman Hertzberger's Montessori school in Delft, Hans Scharoun's Marl School, Hunstanton School by Alison and Peter Smithson, Hasmukh Patel's St Xavier's Primary School, Evelyn Lowe Primary School by David and Mary Medd and a colonial era school in Ahmedabad. Analysis of each case study involved creating justified graphs of the permeability structure (based on the convex map) as seen from the entrance, classroom, etc; the convex maps analysed for integration and choice; a visibility graph and isovist analysis looking at measures like visual integration, angular step depth from entrance etc; and a topological space type classification of the key functions (Hillier, 1996 pp. 245-249). The exercise required students to compare their analysis of spatial configurations against possible social implications to assess whether the layout was conducive to the social/ pedagogical model or intent of each example school.

Having learned from the case studies and literature about pedagogical aspects of schools, the student designers formulated their own social program. Each stated a detailed pedagogical model and some social intentions for the school they would design. These programs, along with some common functions, were then translated to a graph of an imagined permeability structure connecting the typical nodes: entrance, classrooms, common spaces, admin, staff rooms, toilets, activity rooms. In itself the production of the justified graphs of such structures (from say, the school entrance or the classrooms)

became a loaded design exercise, with students exploring the consequences of deliberate changes in the spatial connectivity at the level of the graph itself.

Having somewhat resolved a ‘suitable’ topological graph, each student subsequently explored their translation into possible plan forms, factoring in programmatic functions, area requirements and site conditions as they did so. Once such an initial organisation of the spatial units was in place, the process began to rapidly diversify and diverge, with each student following an individual trajectory. The common themes emerging from these are explained in the following chapter.

4 EMERGENT METHODS

With the broad steps by which design progressed having been outlined, this chapter elaborates on the methodological developments for architectural design put forth by the paper. These are outlined under four themes; Designing through assimilation and iteration; From global to local and back; Path analysis as narrative design; Imagination and speculation and forms of representation.

4.1 Designing through assimilation and iteration

From the case studies set the student designers learned to speculate about the appropriateness of certain configurational attributes for the social or pedagogical models of their schools. Having outlined a social program, they then ‘designed’ the graph for their own school building, referring to their case study findings. These steps followed a sequence of reasoning such as - ‘The case study was a Montessori type pedagogical model housed in a building with a predominance of D-type spaces, this seemed an appropriate spatial affordance (Gibson, 1979) for a pedagogy of free exploration. If my programme has a similar social or pedagogical model let me create for it a permeability graph which has a large percentage of C and D type spaces’ or ‘Classrooms as dead end (A-type) spaces were seen to be suited for instruction/lecture based teaching, whereas my design intends to facilitate more of an exploratory form of learning, with student-initiated peer-learning. Some classrooms therefore must lie of movement loops(C or D type), allowing their occupants spontaneous encounters and catalysing new interactions with people and ideas.’ In such a way, student designers therefore began to critically consider the appropriateness of topological space types for given functions (Figure 1).

Another exemplar of the above approach took inspiration from a Montessori school, from which the student designer sought to achieve a similar socio-spatial quality (Figure 2). Here the designer had learned that the focus of the school does not lie solely in its classrooms (Sailer, 2015). “By emphasizing the role of outdoor spaces, corridors, courtyards and pupil-owned spaces, the school sought to enable social learning processes alongside instruction-based and individual modes of learning”. He therefore aimed to create a highly integrated space, called the ‘activity street’, which became an active, dynamic and engaging area to bring people together over shared exploration of activities and co-presence. The syntactic location of the space at first ‘designed’ or achieved through the convex map ‘proposal’ of the layout that the student produced; later became the subject of further

detailed inquiry, requiring extensive isovist field analysis ()

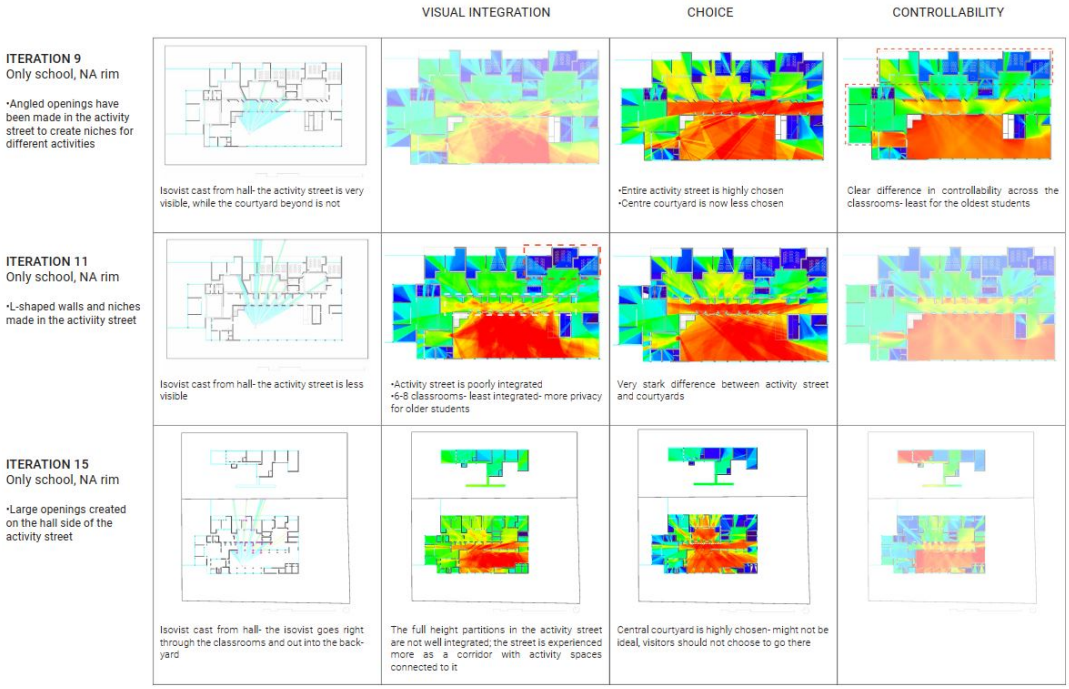


Figure).

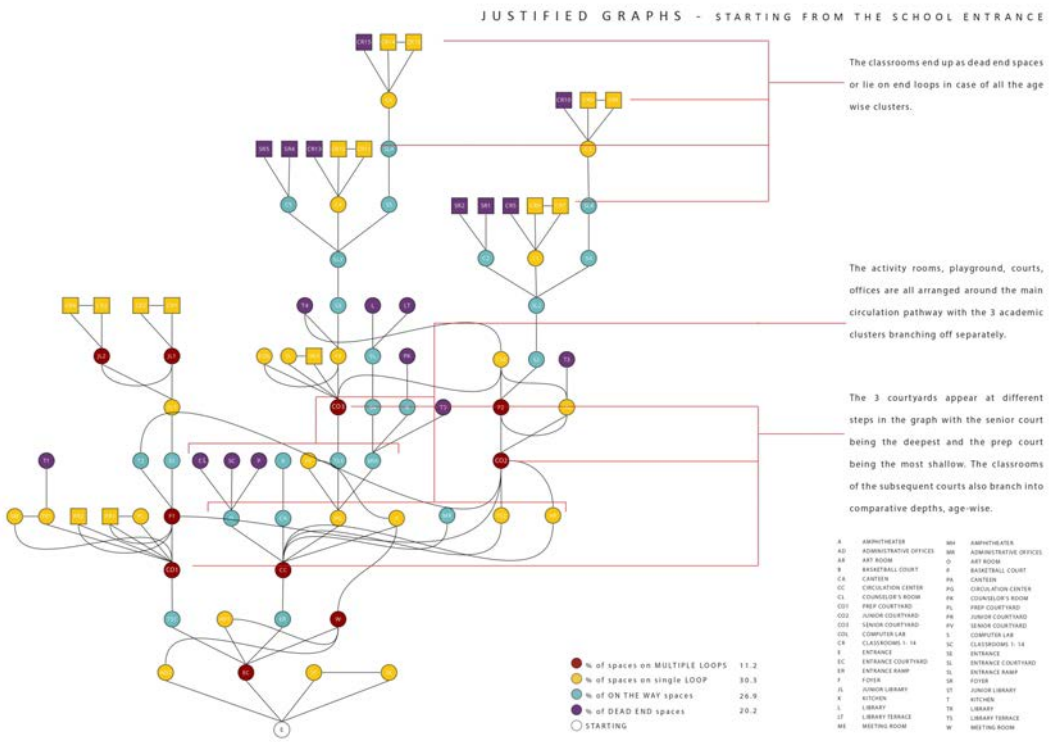


Figure 1: A justified graph from the entrance with colour-coded topological space type classification. Drawn by Baidehi Rej.

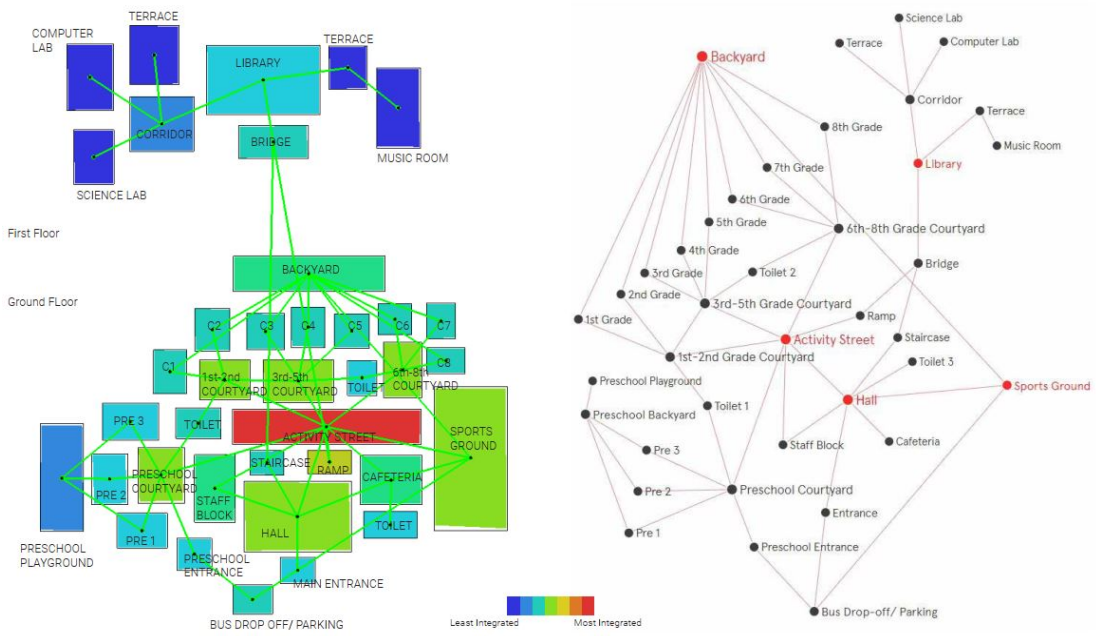
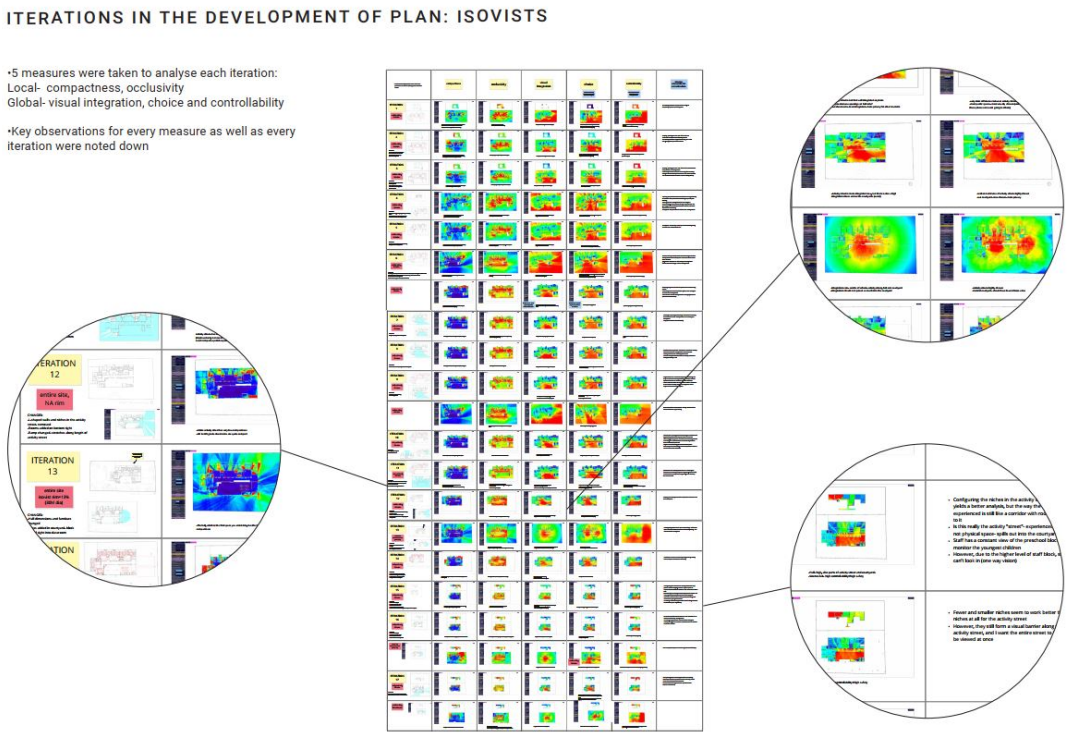


Figure 2: An abstract convex map and the corresponding graph in the initial stages of interpreting the brief. Drawn by Ninad Shroff.

In a third example, the evaluation of how different clustering patterns of classrooms led to different visibility conditions allowed the designer to speculate about associated social consequences. In such an approach, design considerations were focused upon questions including; Are teachers of adjacent classrooms able to see each other as they teach? Is there a threshold space for a student to pause and prepare themselves, before stepping into the view of the teacher and the classroom? (Figure a).

(a)



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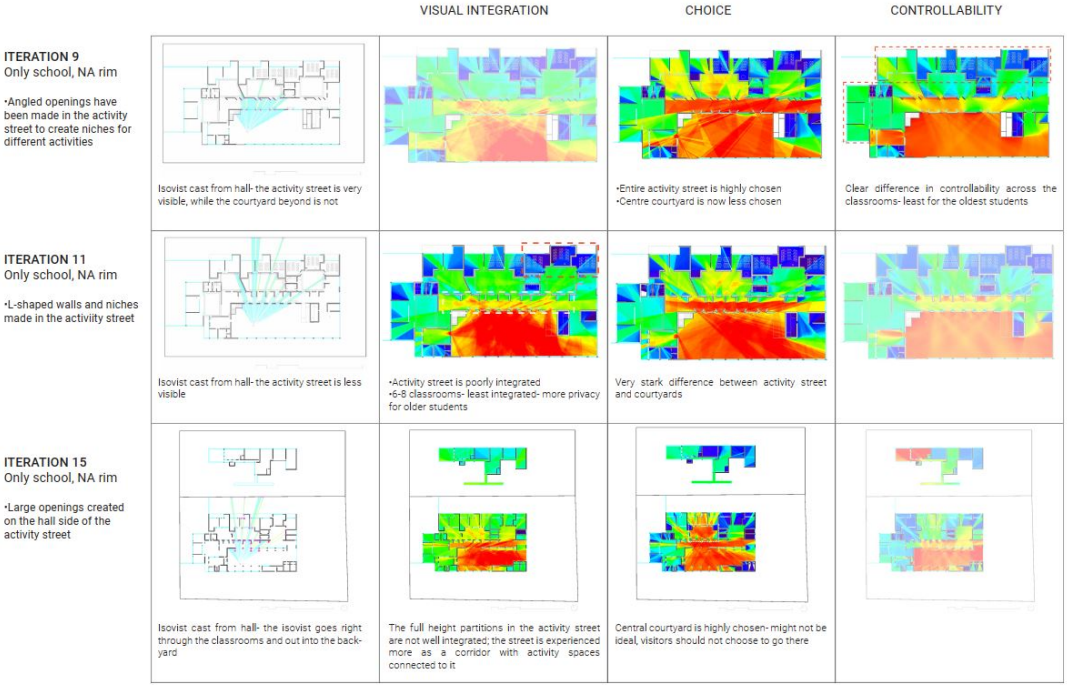
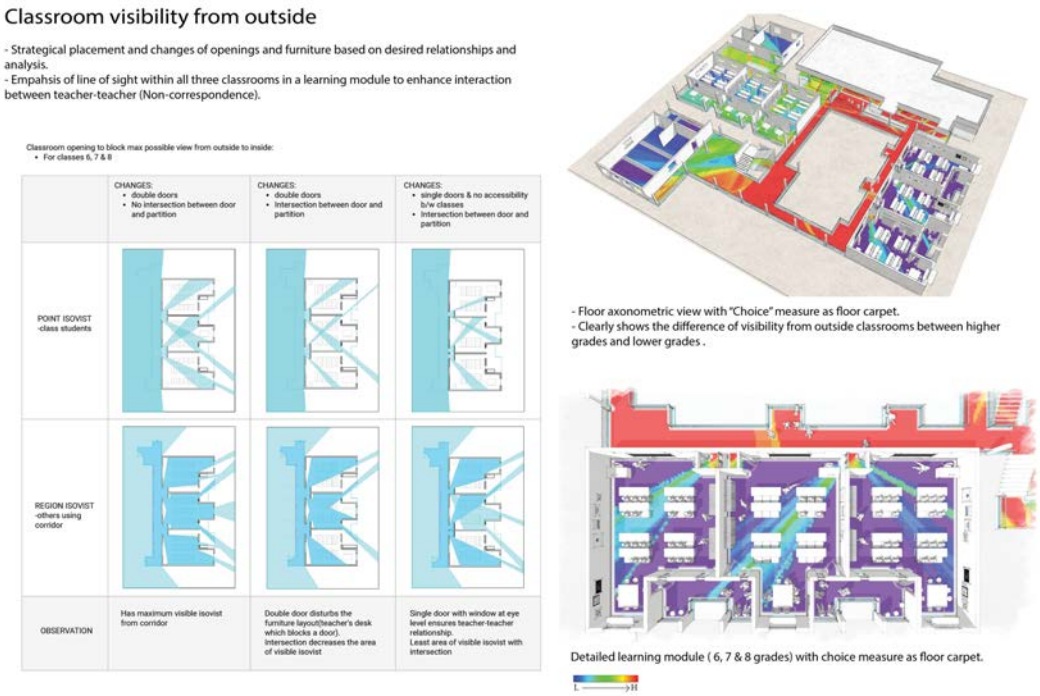


Figure 3: (a) Stages of the iterative process – Visibility parameters being tested at each step of design iteration. Drawn by Ninad Shroff. (b) Isovist_app's visibility measures used to fine tune the details of the design of the design through an iterative process. Drawn by Ninad Shroff

In addressing such questions, visibility analysis was used as a tool to examine spatial relations with precision but also to actively set up relationships between different user groups. With the latter particularly in mind, students began to speculate about the interactions between user 'types' and how the spatial fields that they inhabited might afford, restrict or reinforce such characteristic behaviours. For instance, from a consideration of the probabilistic visual encounters and co-presence between staff

and students, as well as that between senior and junior students, one student began to explicitly configure spatial linkages within which different student age groups typically crossed paths under the visual surveillance of staff; thereby mitigating risk of bullying behaviours while still allowing interaction (Figure b).

(a)



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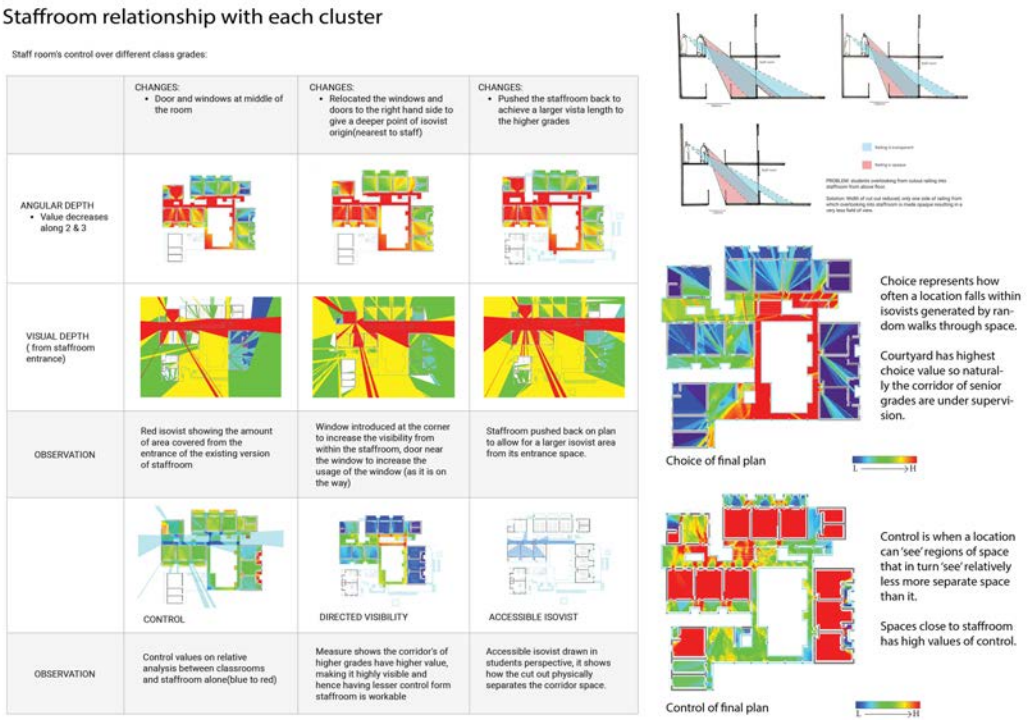

Figure 4: (a) Point and field isovists used to visualise the relationships set up between typical users of the space. Drawn by Sajanish Repalle. (b) Studying the isovists from key locations, occupied by different user groups, checking for potential of co-presense. Drawn by Sajnish R.

In essence, the examples presented demonstrate attempts by the student designers to re-create or avoid certain configurational attributes of the case studies. The latter is being referred to here as design through assimilation, the assimilation being the learning that a certain spatial layout catalyses a certain social phenomenon. Thus speculative correlations assimilated from the case studies became the basis of design ideation in social and spatial terms.

Once such a relationship, between a spatial parameter and the corresponding social or behavioral affordance, was identified as relevant to the designer's intentions, they then attempted to heighten or diminish the desired effect by means of an iterative process of testing, modifying and retesting and re-modifying. In doing so they sought to optimise the layouts potential to serve a 'design intent' and thereby actively speculated about exaggerating the intended experience, affordance or behaviour.

In advancing their speculative thinking, students tended to appropriate and imagine differing metrics, often 'specialising' with those measures and tools that (in their individual speculative opinions as designers) best reflected or allowed examination of the social intentions for the school they were designing. From such a point of specialist knowledge, a process of iterative testing and modifying generally followed. In a typical design development process the designer kept testing modifying and retesting to both explore and then also better align their developing design with a stated intention ()

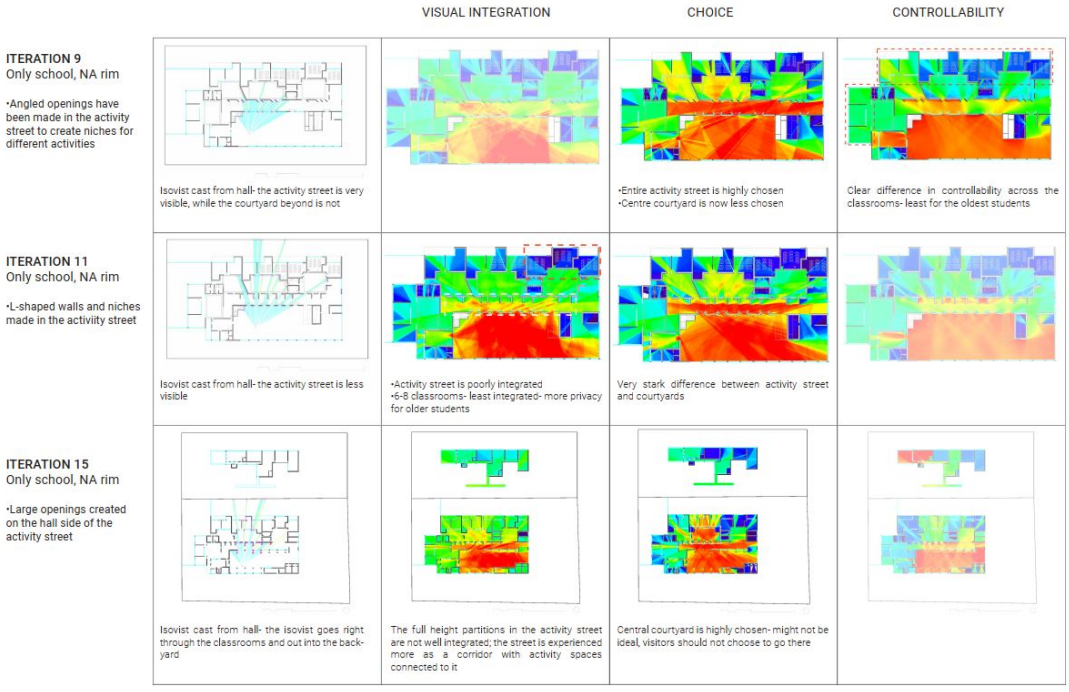

Figure a & 4b). The resulting iterative method was a key characteristic of designing through analysis.

4.2 From global to local and back

Though initial ideas of overall organisation of space came from the graph of convex spaces, the global nature of convex graphs generally precludes consideration of a finer grain of the structuring of space at a building interior scale. In order to achieve the latter, students utilised isovist in a next set of detail

level questions, for instance considering how the various aspects of visual experience might be influenced by column spacing, door and window placements, furniture layouts and so forth. More successful students were able to subsequently connect the effect of modifications at the latter local level, back to their impact at the configurative global level.

The ability to identify how changes at a small scale (local changes influence the whole system (global changes) was another characteristic design-thinking ability facilitated by the analytic approach. For instance, the chamfering of orthogonal corners at wall intersections increased the average value of visual integration across the plan making it a more visually integrated layout overall (Figure 6). This ability, of what may be considered fine architectural detail, to influence global configurational attributes (metrics such as visual integration) was increasingly used by student designers in the process of finer refinement and resolution of the design. By testing and modifying one could identify with precision the effect of design decisions such as the positioning of staircases, spacing of columns; orientation, location and sizing of windows and doors. In turn the cycles of modification, analysis and reflection that arose themselves drove further forms of speculative and imaginative design.

4.3 Path analysis as narrative design

In the act of designing a building with a social and pedagogical intent, it was found to be of value to speculatively inhabit the lives of its users. To do so, in one exercise students were asked to write about the imagined, typical or daily journeys of a user (student or teacher) of the school they were designing. From these, a path isovist analysis (visualised as a trend-line of a particular isovist metric over the course of the route followed) was used to then examine, empirically, how close such imagined experiences were to those suggested (to actually occur) by the analysis. Patterns of the trend-lines were read in conjunction with the narrative to assess the synchrony between the imagined and the realised. Doing so began by laying out parts of the journey in conjunction with the trend-lines of the isovist measures (Figure 3).

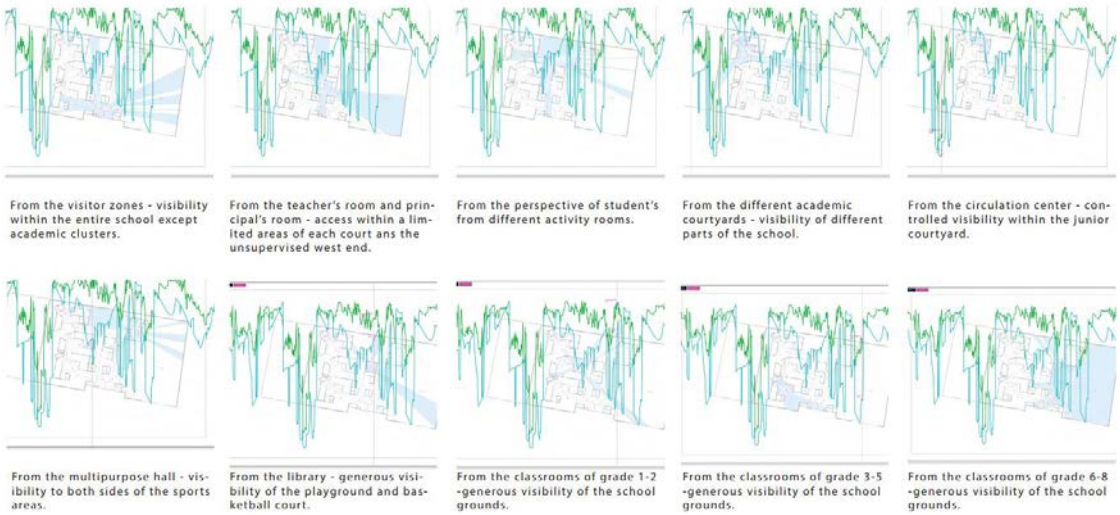

Figure 3: Parts of the written narrative seen in conjunction with the trend-lines of the isovist measures at the corresponding parts of the journey.

The rate of rise or decline of a metric was examined along with the written imagined journey; a gradual rate was taken to represent gradual transitions in spatial experience, whereas a sudden change (near vertical ascent or descent in a metric at some points) was interpreted as a sudden shift, or threshold of experience. The respective desirability of each form of change was considered relative to real and imagined individual characteristics; for instance, if the designer had intended a journey with a gradual transition in some aspect of socio-spatial experience, then an abrupt change (steep rise or fall) was seen as contrary to that intention. In such a way, designers deduced the synchrony between the imagined experience and what the analysis was suggesting [Figure 4]. A typical case considered by the designers was; whether the student's every day journey from the school's entrance to the classroom was meant to be experienced as a gradual transition from the dynamic and stimulating outside to the focussed study environment inside. Metrics imagined to facilitate this included compactness, occlusivity and drift. A path isovist where the trend-line for compactness gradually reduced was considered to be in sync with this intention, whereas one were the compactness dropped very suddenly on entering a classroom was thought to be at odds with it.

The peaks and troughs in isovist path trend-lines were seen as high or low points of the experience. This helped to design high points in the 'daily journey', where along the course of the path, for instance, a longest vista became apparent, or where occlusivity suddenly peaked on entering an informal gathering space. Students considered where peaks and troughs occurred, attempting to reconcile their corresponding location with appropriateness within the journey (Figure 4). From such comparisons, a corresponding social meaning was inferred and designed for. For instance, in an attempt to design for introverts and extroverts equally, a student designer sought to examine how commonly on their daily journey a building inhabitant might encounter peaks of visual integration, assuming that reducing these spikes would make the introvert feel less exposed and more comfortable. Such an approach may be readily expanded in an

accumulative manner, to include the idea of integration value gathered along the path (Pachilova, et al., 2020).

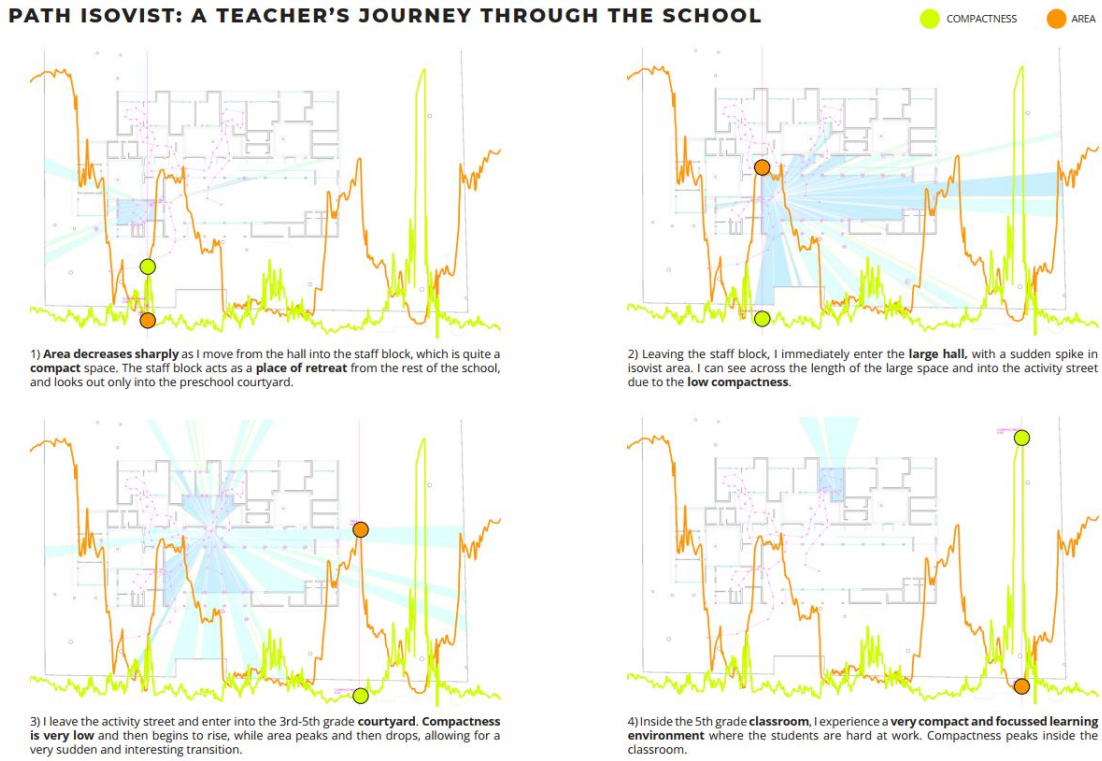

Figure 4: Path isovist analysis, visualising the plan view along with the trend-lines of isovist area and compactness. Drawn by Ninad Shroff

The field analysis made visible some relevant but invisible lines – lines delineating the stark change between low and high values of a metric, typically occurring along the occluded edges (Benedikt, 1979) of the isovist from the centre of a large space. On passing such a line, the analysed measure and so too the experience (presumably) commonly changes drastically. Reading the path analysis in conjunction with the field analysis designers could identify where their journeys crossed these lines. The fine grain of isovist analysis therefore revealed these hidden experiential thresholds which the designers then strategically modified to create the desired social conditions.

Using some of these methods of imagining, examining and modifying journeys within their design, was akin to narrative design, strongly acknowledging the temporal nature of human experience within space, albeit with a precision and insight not afforded by conventional modes of architectural drawing.

4.4 Imagination and Speculation, and forms of Representation

The methods employed were ultimately assimilated and used creatively as tools of imagination. In doing so, student designers critically expanded the possible meaning and interpretative reading of the spatial unit, such as isovists, as well as the spatial analysis produced from them.

A typical representative example of such imaginative approaches is that of collaging the isovists back into the designers' proposals. Throughout the process there was much curiosity from the

student cohort regarding aspects of (and potential for) three dimensional analysis. Whilst an obvious urge and frustration (i.e. not being able to examine the third dimension) did express itself, the absence of a literal 3D analysis provided the imaginative and speculative space for work that sprang from, but went beyond the confines of, technical accuracy here. An example of this is a semi-realistic axonometric, in which imagined 3D isovists were freely used to leverage and explore further design ideas and affordance opportunities (Figure 5).

Figure 5: A collage-like representation of the imagined school using 3D isovists as a tool to think of visual connections across multiple floors/levels. Drawn by Dhrumin Patel

Throughout the course of the studio, key modes of drawing emerged as ways to visualise the analytic insights simultaneously with other layers of spatial information. One such mode of drawing successfully overlaid the results of visual field analysis as a carpet on an exploded axonometric

drawing (Figure 6). This form of drawing brought together syntactic and morphological information while designing.

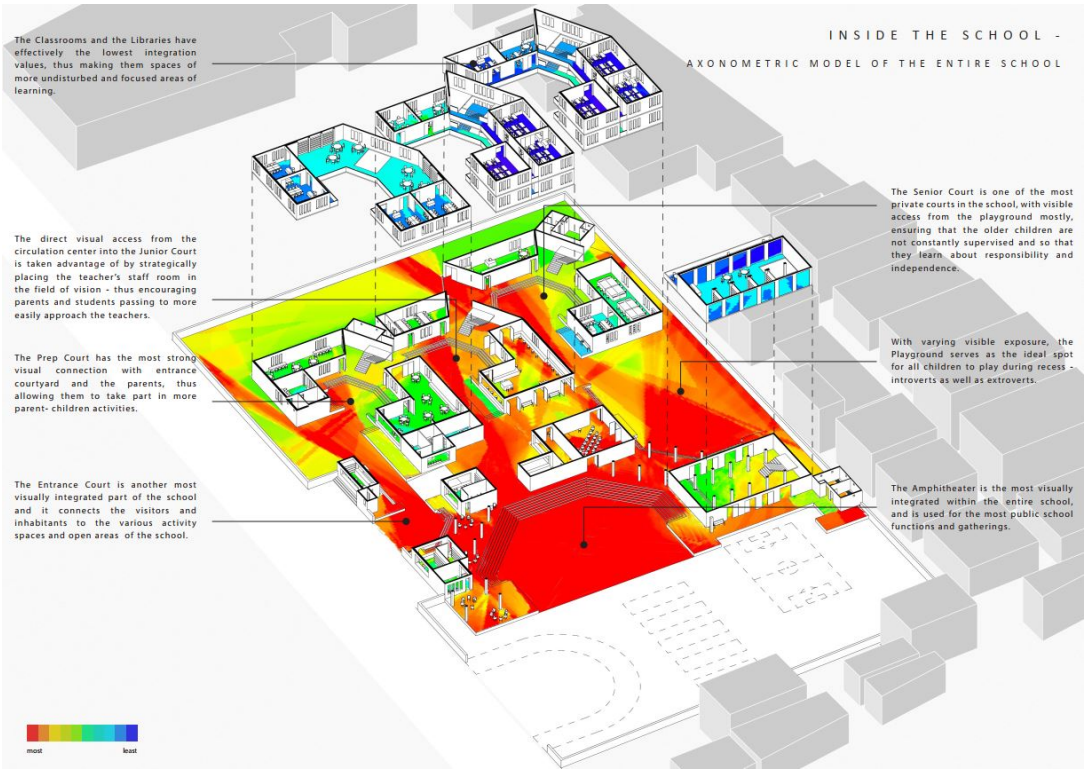

Figure 6 : Exploded axonometric drawing with Visual integration analysis overlay. Drawn by Baidehi Rej

In a second form of representation the student draws a perspective view from one of the points of highest visual integration value, populated with much social activity and interaction (Figure 7). Selecting a relevant location based on the analysis and populating it the way the measures suggested gave a way of bringing life to perspectives, but also simultaneously informed interpretation of the analysis fields. These drawings looked similar to perspective visualisations which architects draw, but contained in them an informed imagination of how the setting worked socially. We called these drawings ‘social perspectives’.

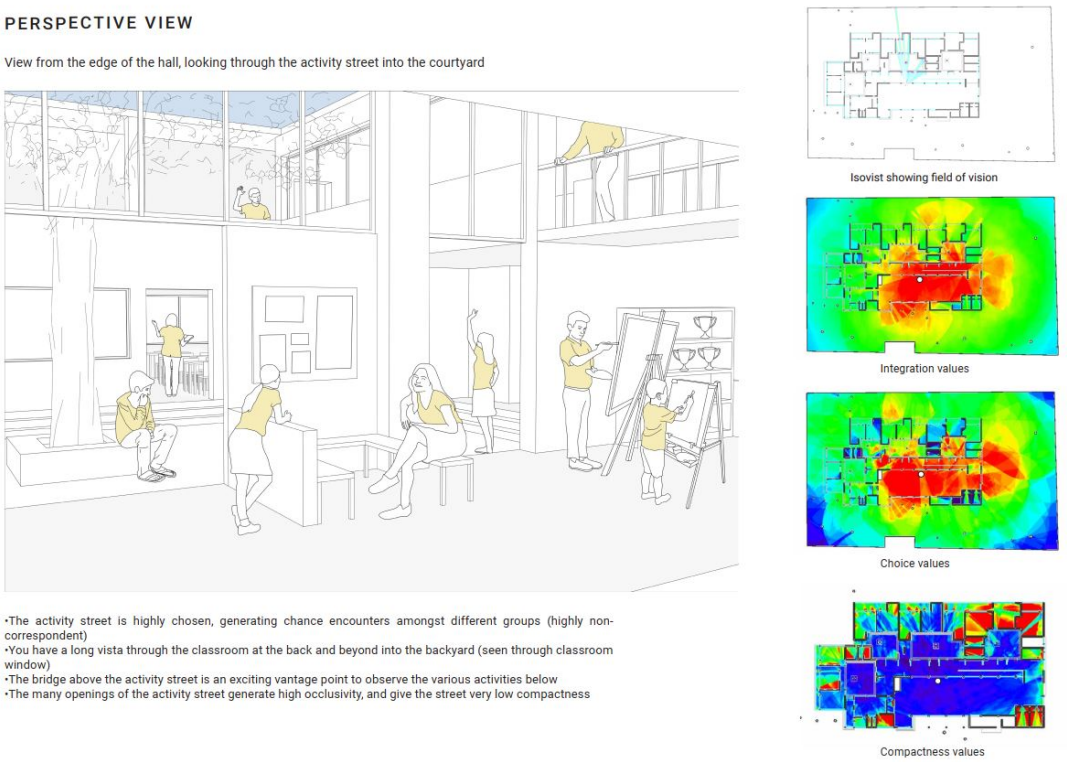

Figure 7: 'Social Perspective' view, with corresponding visibility analysis metrics. Drawn by Ninad Shroff

Bringing together multiple such analyses in different drawings to create a coherent picture of the way the layout worked was a compositional method employed for presentation. In Figure 8 the composition allows one to see that the visual integration core for the enclosed space lies within a central courtyard whereas the permeable integration core (using the convex map) is more towards a different cluster of spaces. Such insights were gleaned by the graphical or compositional juxtaposition of different drawings and analysis. Not often used in research, the technique became indispensable for visual-thinking architects and design practitioners.

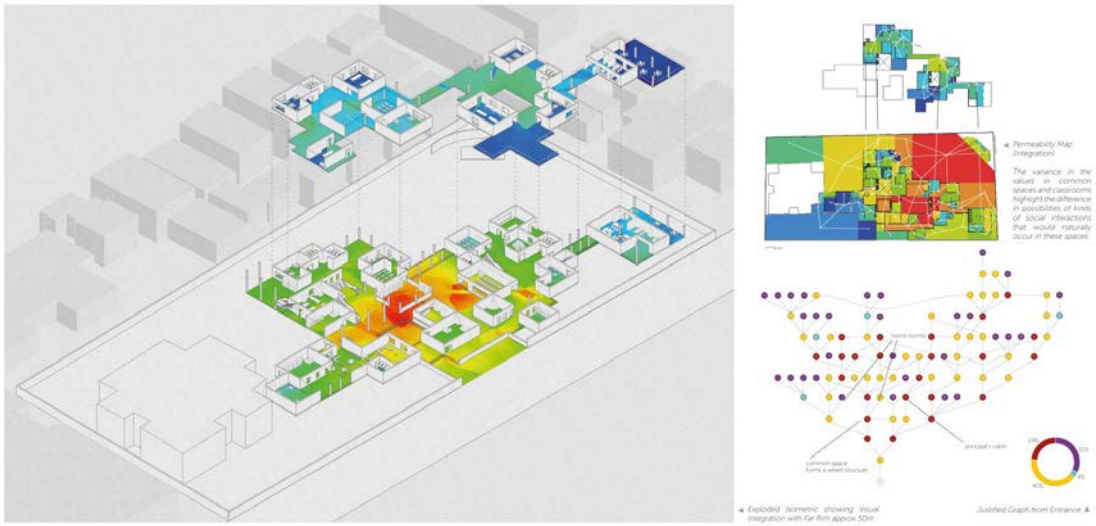

Figure 8 : 10a: Exploded axonometric view with visual integration (radius approximately 20 meters) overlay as a carpet. 10b: convex map of the interior and exterior spaces analysed for integration (HH); 10c: Justified graph of permeability connections with topological space type classification by colour. Drawn by Dhrumin Patel

5 INFERENCES

The following chapter outlines key observations about the studio considered to be a result of the introduction of analytic methods in design. We include findings on how these design methods influenced the design process and the pedagogical process; how the analytic tools themselves were used differently from the way they are employed in research terms; and how design decisions arose from an evidence-based and iterative process.

5.1 Influence on the design process

Using insights gleaned from case study analysis, followed by analysing their own designs, student designers were able to design schools which were in line with their stated social and pedagogical intentions. Doing so was enabled by the application of tools to examine the synchrony between the intended social system and the designed spatial system. Through such a process, students were also able to test their assumptions about the efficacy of a design solution vis-à-vis a stated intention. The latter finding may be seen as one of the key learning outcomes of the studio.

Though the planning of the studio was based on a study of the relevant literature, research, and established correlations, the students in it used the tools in a speculative way. As, for instance, the research on the social implications of the various isovist (local) measures is still relatively sparse, that same sparseness opened up possibilities of freer speculation about what the measures could mean. Examples included thinking of high ‘drift’ values as offering locations which allow people to observe without being overly exposed themselves, thereby encouraging a shy person to recede into these spots and gradually drift towards activity at a comfortable pace. Based on initial suggestions by the tutors, students became increasingly confident at advancing their own such unique speculations; doing so itself aided a creative imagination of how social phenomena may be facilitated by spatial attributes.

A key feature of the process followed is that it was not parametric or generative, in that the designer’s creative impulses and intuitions were an essential actor in design. A rare deviation in approach was noted when some students made design decisions with the intent of optimising a single isovist metric. In such a case it was observed that the design modifications over multiple iterations often compromised other existing spatial qualities of the design. The latter may be seen as a limitation in a process which uses analytic tools and computation - that it risks inducing a tendency to indiscriminately and singularly pursue a certain numeric outcome, at the cost of overall design qualities. The importance of holistic speculative thinking as observed elsewhere in our processes is inherently obvious here.

The capability of space syntax methods to analyse the spatial configuration as a whole made visible the impact of local changes on the global system. As described in the section ‘From local to global and back’ such a feedback loop allowed informed consideration of finer architectural detail. Perhaps more importantly it also made the design process non-linear compared to a more conventional

progression from smaller (1:200, 1:100) to larger (1:10, 1:20) scales, yet maintained a sense of coherence and understanding. The thought process instead involved a feedback loop between different scales of intervention each influencing the others.

The isovists.org toolset (or Isovist_app) developed by Sam McElhinney, UCA and Michael Benedikt, University of Texas at Austin, provides very high (pixel) resolution and rapid (near real time) display of results; “poised to enter both design and design research processes fluidly and a visually arresting way” (Benedikt, et al., 2019 p. 1). In the process of plan development, the speed of the isovist_app software made feasible a rigorous process of ideation-speculation-iteration-modification. Designs developed through many cycles of testing, modifying and testing again. Through the process students iterated their designs to modify particular metrics in key locations whilst speculating about what such iterations meant as a social consequence for the inhabitants of their designs. The speed of these toolsets allowed students to test quickly and in detail, how their design decisions were affecting outcomes. The software’s graphical sophistication and high resolution results, helped architects who are visual thinkers to use drawings to understand the numeric data produced, and further facilitated intriguing novel forms of design-representation approach.

5.2 Influence on pedagogy

The initial part of the studio was an introduction to the science of space syntax with a definitive terminology, concepts and theory. This phase followed a straightforward lecture based, instructive model of teaching, where the process was strictly prescribed and expected to give a pre-defined output. The latter may be seen as significantly different from a typical design studio where initial phases are more open ended as students begin with a creative and imaginative process of coming up with abstract design concepts and each individual process may vary. Having assimilated the empirical processes, each student designer latterly interpreted the meanings of the tools and their metrics (as well as how to design with them) in their own unique way.

The process established allowed rethinking of first principles by testing them through analytic tools, thereby questioning the usual assumptions about space which students accumulate as they go through architectural studies. A common observation by the critics, students and tutors alike, was that the objectivity and empirical approach which space syntax methods brought, gave the designers a lot of confidence and ownership of their ideas; areas which are too often relegated to ‘subjectivity’. The latter was particularly reflected in an objectivity and authority in how students presented their designs, as well as being apparent in the dynamics of authority observed in the discussions between tutor and student. Often the traditional roles were reversed here; having analysed multiple iterations and observed the impact, the student designer tended to be more aware of and knowledgeable in the impact of a design decision than the tutor. Having devised their own ways of using the analysis, identified their own speculative aims, and developed their own forms of representation, the students largely led said dynamics.

6 CONCLUSIONS

At the most fundamental level, the tools of analysis were used in design as 'ideas to think with' (Hillier, et al., 1997). Whether examining the form of the visual field or the network centrality of a point in their layouts, the students were accessing information about and discovering layers of their designs which are typically unexplored in design studios.

Architects, with much normative theory, are typically ill-equipped with evidence-based analytic knowledge to be able to test their designs against their design intentions (Lang, 1987). In the CEPT studio, there was a marked effort by the designers to use socio-spatial knowledge from space syntax research to test and guide their designs towards suitability for the social intentions. This was the first notable influence the analytic methods of space syntax may have been said to have on the design process, that designers used the tools to constantly examine the efficacy of their creative ideation in furthering the social intention of their designs.

About his extensive work teaching analytic urban design Karimi states : 'Based on the outcome of student projects, it can be confidently claimed that at least in some cases, the analytical process itself generated the core design ideas. But in some projects the core ideas were not necessarily the direct results of the analytical research.' (Karimi, 2019). In the studio described here, the approach was to use the methods of analysis as design tools, for example by deciding which function was to have a high integration value, and then designing a layout which achieved said aim by trial and error. In such a way one may say the designs produced inherently arose from analytic methods. Further, the design processes discussed here employed computational methods at their core, yet unlike parametric or generative design work-flows, they were steered by the active involvement of the designer's decision making and creativity.

As the field of space syntax becomes increasingly methodological and technical, relative to its original focus which was on theoretical developments (Psarra, 2019) our work attempts to stretch the boundaries of 'how' analysis can be meaningful within the act of design thinking. The pressing need for theoretical development to catch up in space syntax study may have its answer in part in active application of the existing analytic knowledge in the creative process of design. The speculations within such experiments as the one described here can generate pertinent hypothesis for further research, eventually geared towards creating theory on the generative possibilities of space syntax. The speculative usage of the tools and metrics, mentioned in the previous chapter, shows how the application of these methods in design has the potential to influence and expand the use and interpretation of the space syntax methods and metrics themselves.

Demonstrated within the limited case at hand, the given tools – DepthmapX, used for quick iteration with convex maps and Isovist_app, used for rapid detailed visibility testing, showed promising results. The suggestion is that the capability of rapid and approximate analysis can catalyse a shift from current apprehensions; i.e. that the strictness of space syntax methods is limiting to the creativity

expected within a design process. The application in creative processes therefore also suggests that there is a need for further development of toolsets which afford such appropriate functions.
A key takeaway of the exercise has been to demonstrate the possibility of using strictly scientific analysis in a speculative and imaginative way within a creative process. The socio-spatial knowledge base of space syntax was used as a springing point for ideation rather than the norm of using it as a deterministic test of the validity of a design. It is suggested here that such an approach allows such knowledge to more readily and more usefully enter the design studio, where it surely has much to offer.

The use of analytic methods influenced the design process; this had corresponding influences on pedagogical processes. Summarising the detailed description of this in the previous chapter, it may be said that the objectivity, rigour, precision and evidence based theoretical grounding of the space syntax methods resulted in self-directed learning and ownership within the student's learning approach.

The ideas of design methodologies emerging from this studio present potential for much further development. The setting of taught architectural design studios is seen here as a suitable environment for such exploration and future development, and one which it is hoped will become more commonplace in future.

REFERENCES

Arnold, T. (2011). Using Space Syntax to Design an Architecture of Visual Relations. *Journal of Space Syntax*, 201-222.

Bafna, S. (2012). THE IMAGINATIVE FUNCTION OF ARCHITECTURE: a clarification of some conceptual issues. *Proceedings: Eighth International Space Syntax Symposium.* santiago de chile.

Benedikt, M. (1979). To Take Hold of Space: Isovists and Isovist Fields. *Environment and Planning B: Planning and Design. 6.*, 47-65.

Benedikt, M., & McElhinney, S. (2019). Isovists and the Metrics of Architectural Space. *ACSA 2019: BLACK BOX: Articulating Architecture's Core in the Post-Digital Era.* Pittsburgh.

Dalton, R. C., & Dalton, N. S. (2001). OmniVista:an application for isovist field and path analysis. *Proceedings of the 3rd International Space Syntax Symposium.* Atlanta, Georgia.

Dursun, P., (2007). Space Syntax in Design. *Proceedings of the 6th International space syntax Symposium.* Istanbul.

Gibson, J. (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin.

Hanson, J. (1987). Ideas are in Things: An Application of the Space Syntax Method to Discovering House Genotypes. *Environment and Planning B: Planning and Design*.

Hillier, B. (1996). *Space is the machine.* Cambridge: Cambridge University Press.

Hillier, B. (2019). Structure or: does space sytnax need to radically extend its theory of spatial configuration . *12th International Space Syntax Symposium*.

Hillier, B., & Hanson, J. (1984). *The Social Logic of Space.* Cambridge: Cambridge University Press.

Hillier, B., & Hanson, J. (1997). THE REASONING ART: or, the need for an Analytic theory of Architecture. *Space Syntax First International Symposium.* London.

Karimi, K. (2019). Space Syntax as a platform for teaching analytical, research-based. *13th International Space Syntax Symposium*, (pp. 268-1). Beijing.

Karimi, K. (2019). Space Syntax as a platform for teaching analytical, research-based design: a pedagogical experince. Beijing: Proceedings of the 12th Space Syntax Symposium.

Krenz, K., Psarra, S., & Koustorou, F. (2017). *E-merging Design Research: Pop-Up City | MSc Spatial Design: Architecture & Cities.* London: The Bartlett School of Architecture, UCL.

Miranda, P., Koch, D., Izaki, A. (20130). Spot with Paths, and Interactive diagram with low complexity Isovist Algorithm. *Proceedings from the 9th International Space Syntax Symposium.* Seoul.

Nourian, P., Rezvani, S., & Sariyildiz, S. (2013). Designing with Space Syntax A configurative approach to architectural layout, proposing a computa- tional methodology. *31st eCAADe Conference.* Delft.

Pachilova, R., & Sailer, K. (2020). Providing care quality by design: a new measure to assess hospital ward layouts. *The Journal of Architecture*, 186-202.

Psarra, S. (2013). Beyond Analytical Knowledge: The need for a combined theory of generation and Explanation. 065:1-22.

Sailer, K. (2015). The spatial and social organisation of teaching and learning - The case of Hogwarts School of Witchcraft and Wizardry., (p. 34:1).

Sailer, K., Koutsolampros, P., Varoudis, T., & Haslem, R. (2019). Dissecting Visibility Graph Analysis: The metrics and their role in understanding workplace human behaviour. *12th International Space syntax symposium.* Beijing.

Schneider, S., Kuliga, S., Holsher, C., Conroy-Dalton, R., Kunert, A., Kulik, A., Donath, D., (2013). Educating Architecture Students to Design Buildings from the Inside- Out : Experiences from a research-based design studio. *Proceedings from the 9th International Space Syntax Symposium.* Seoul.

Trova, V., Back to the Fundamentals: The step and the Eye. *Proceedings of the 12th Space Syntax Symposium.* Beijing.

Van Nes, A. (2019). Various Morphological Analysis Methods Applied inIN Teaching. *Proceedings of the 12th Space Syntax Symposium.* Beijing.

Yamu, C., Nes, A. v., & Garau, C. (2021). Bill Hillier's Legacy: Space Syntax—A Synopsis of Basic Concepts, Measures, and Empirical Application. *13*(1-25).

Zaky, F. A., & Sailer, K. (2017). The Impact of Spatial Design on the Learning process and Students' Socialisation: A Study of Secondary Schools Within the UK. *11th Space Syntax Symposium.* Lisbon.