#194

GENERATIVE URBAN DESIGN MODULE:

Integrating Space Syntax and Spatial Cognition Experimental Methods

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ABSTRACT

Traditional planning tools often fail to respond to the rapid changes of the urban context. In this paper we suggest to explore how new methods of spatial analysis together with advances in behavioural research of spatial cognition can be used to support an alternative approach, in which adaptive design systems are able to respond more accurately to the needs of the contemporary city and its dwellers. We present the results of the educational module, where quantitative research techniques, traditionally developed as part of Space Syntax, were introduced in conjunction with qualitative behavioural methods. Architecture students were familiarized with the basic techniques for evaluation of spatial configurations, including isovist, viewshed, axial mapping and visibility graph analysis. At the same time, they were presented with perceptual concepts from cognitive and environmental psychology, such as orientation, wayfinding, navigability and intelligibility. To analyse an urban site, to evaluate design outcomes and to compare alternatives, the students were taught methods used in research of human spatial cognition, such as observations, behavioural experiments, in-depth interviews, cognitive mapping and virtual reality tracking. Finally, these innovative methodologies were synthesized by use of parametrization and optimization frameworks to explore developing of generative design systems in urban domain.

KEYWORDS

Configuration-informed urban design, generative tools, research-based design, spatial cognition, pedagogic methods and experience

1. INTRODUCTION

Urban Design is an indispensable activity where the dynamics of contemporary social and technological conditions continually introduce unforeseen changes. Rigidity of the traditional planning tools fail to respond to the rapid changes of the urban context (Batty 2013; Mehaffy, 2008). New methods of spatial analysis together with advances in behavioural research of spatial cognition can be used to support an alternative approach, in which adaptive design systems are able to respond more accurately to the needs of the contemporary city and its dwellers (Marcus et al, 2016; Dalton and Hoelscher, 2007).

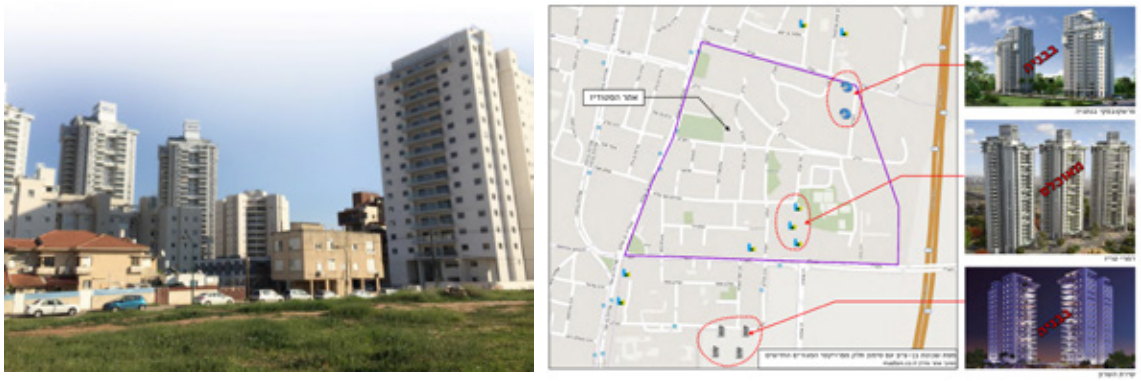
This paper discusses the results of the educational module, where quantitative research techniques, traditionally developed as part of Space Syntax, were introduced in conjunction with qualitative behavioural methods (Montello, 2007; Hillier, 1996). This experimental module was integrated in an urban design studio together with theoretical studies on qualitative research in the field of cognitive psychology. The module aimed to familiarise architecture students with research-based design and to examine how this approach could contribute to new strands in architectural practice and education.

2. DATASETS AND METHODS

One semester design studio was combined with training on cognitive user aspects, excursion, and navigational experiments in immersive virtual reality laboratory. The studio was oriented towards discussion of contemporary processes and trends in urban renovation and aimed to examine conceptual alternatives in the design of large scale urban projects.

The main assumption of the studio was that urban planning in general and residential planning in particular cannot be introduced solely from top down, but must allow some flexibility of the system's lower components in order to influence the entire planning process (Batty 2013). Through exploration of ideas in cognitive science and environmental psychology, we examined the principle of mass-customization in the creation of new residential neighbourhoods.

The site chosen for the re-design was located in Ben-Zion Neighbourhood in Netanya. This neighbourhood which was established in the 30's of the 20th century and traditionally populated by immigrants, is found today in an accelerated process of urban renovation (Figure 1).



a) b)

Figure 1 - Ben-Zion Neighbourhood in Netanya, Israel. (a) One of the current views o the neighbourhood; (b): City map with official proposals for future development (Courtesy of madlan.co.il).

The site reflects tension between formal institutional planning for housing, an intense commercial pressure of real estate and informal illegal development of local dwellers.

The Office of Netanya's City Engineer was part of the studio and contributed to better understanding the current tendencies of ongoing development in the area.

Most importantly, students' design process was supported by a series of theory lectures exploring the role of human perception and cognition in built environment. These lectures aimed to address following objectives:

- Conceptual framework of user behaviour and cognition in built environment.
- Methods and tools for assessing user cognitive performance.
- Study and analysis of key architectural elements affecting spatial cognition.
- Understanding of the role of urban designers and architects in analysing spatio-cognitive aspects.

Practical learning topics included: elements and structure of cognitive representation, cognitive mapping, spatial knowledge acquisition and perceptual concepts from cognitive and environmental psychology, such as orientation, wayfinding, navigability and intelligibility (Montello 2007; Weisman, 1981). Students were familiarized with the basic techniques for evaluation of spatial configurations. Among them a number of methods and computational tools for assessment of environmental quality characteristics affecting performance of urban spaces: (1) visual accessibility, (2) study of the isovist and viewshed and the ways to estimate them. As well as related cognitive issues such as visual exposure, security and safety (Benedikt, 1979), (3) measurement of movement by Space Syntax axial mapping, visibility graph analysis and other graph-theoretical measures (Natapov et al, 2013; Turner, 2001; Turner Penn,1999), (4) innovative technologies in virtual reality and eye-tracking (Natapov and Fisher-Gewirtzman, 2016; Portman, at el, 2015). Study of each method was accomplished with practice of the relevant computerized tool. These methods were used to analyse given urban morphology of the site, to evaluate design outcomes and to compare design alternatives. Finally, these innovative methods were synthesized by use of parametrization and optimization frameworks to explore options of developing generative design systems.

3. RESULTS

In order to meet existing urban conditions and market demands, different variations of computer-aided mass-housing production systems were proposed. These systems enable the automation of urban data collection, pattern generation and construction on site. By integrating the systems with the processes of urban planning, fitting architypes and final adjustment, mass customization can be realized in the housing industry. While design principals of mass customisation are applied to many high tech industries, such solutions are still missing in the residential sector; although they could match a variety of urban individual forms and styles. For now the governing principle of housing design is based on the industrial assembly-line production of replicative units to form buildings and entire neighbourhoods.

A generative potential of the conjunction between digital tools and cognitive methods allow the use of parametrisation techniques as a design and conceptualisation tool for the changing needs of urban population as well as for the development of a new architectural language. The projects in the studio used different methodologies to integrate urban phenomenon of emergence with planning prescriptions to be able to process from the bottom up. These methodologies work as an interface allowing the synthesis of bottom up and top down processes in the urban domain. They are adapted to complex urban systems and show a unique flexibility.

In this short paper we present a sample of the most representative projects developed in the studio (Figures 2 and 3). The project in Figure 2 analysed common Israeli dwelling typologies and explored a correlation between the physical settings of the built environment and the street's sense of community. Students have argued that understanding the correlation may help to design better streets and dwellings, with a potential to support a strong sense of community. They used parametric mapping (Grasshopper) and two Space Syntax tools (visibility graph analysis and justified graphs).

Three housing typologies were analysed: private houses, tower blocks and project houses. The methods used by students allowed them to evaluate and quantify the relation between the dwellings units themselves and between the dwellings and the street. In addition, these analytical methods allowed to compare the different environments.

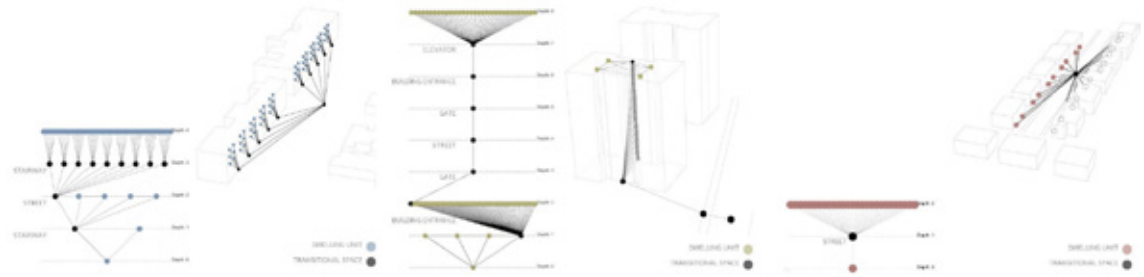
In the small specimen of the research, students found a correlation between the sense of community and the physical settings. There is a correlation between environments with a deep justified graph, the distance from the street, and the percentage of people they knew in their community.

Figure 3 shows another project that started from a critique of the ongoing housing proposed by developers which is primarily concerned with quantitative market-oriented parameters with little reference to human scale. There are large areas of open space in the plans, however, they

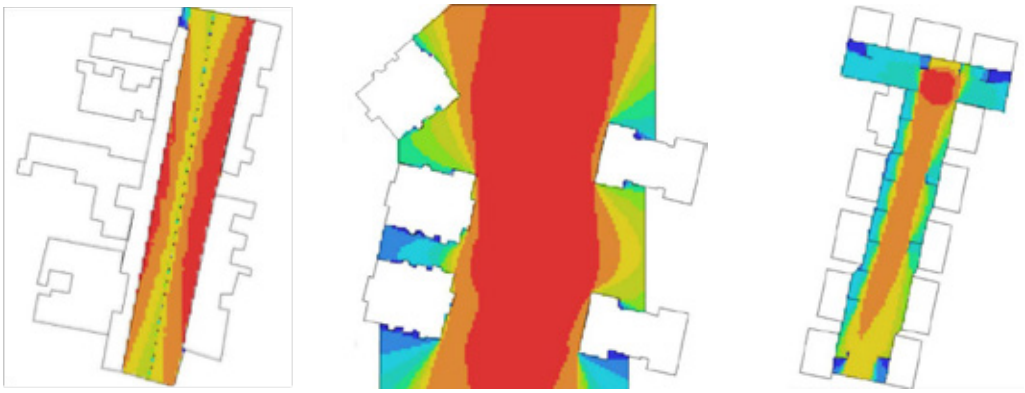
are not developed, badly connected and full of fences and parking lots that block pedestrians' view. The project chose to focus on in-between spaces - the spaces between the buildings in the neighbourhood. It tried to examine these spaces through the lens of human scale perception and to use this approach as a tool to look at housing development in Israel.

(a) private houses (b) tower block (c) project houses

Survey of sense of community in three common Israeli dwelling typologies: a, b and c.



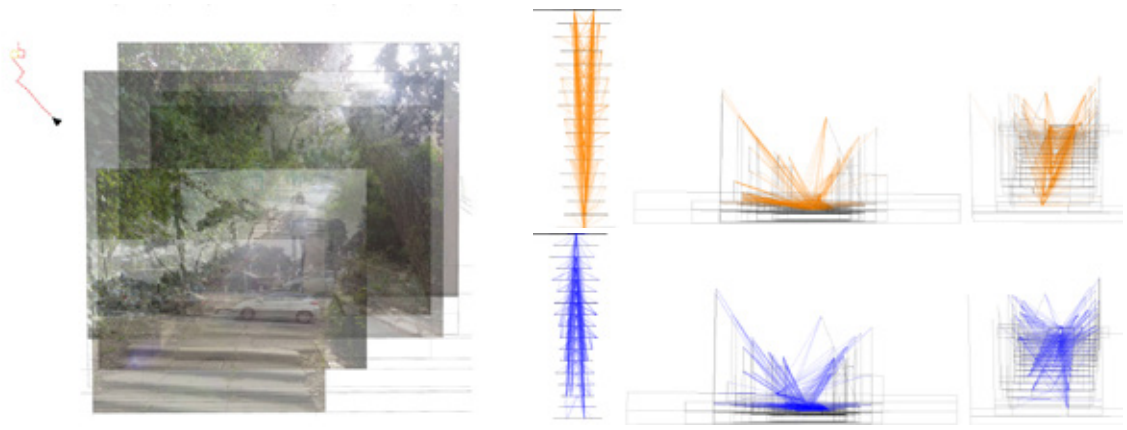
Justified graphs of the three typologies: a, b and c.



Visibility graphs analyses of the three typologies (DepthmapX, Turner, 2001).

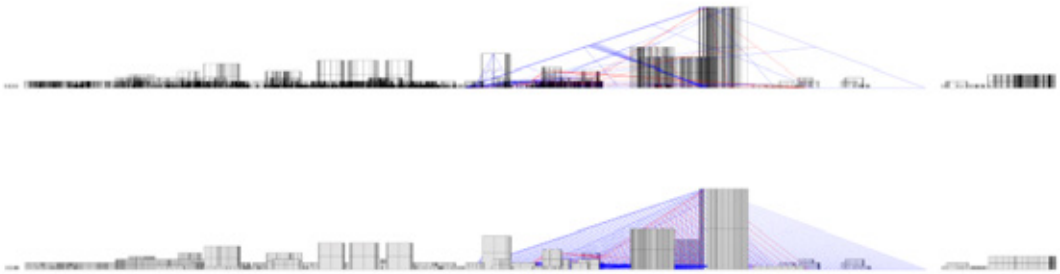
Figure 2 - Project entitled "Street-Dwellings Relations", authors Sheer Han and Adi Kupershmit.

The idea of the project was to create a new system of spaces that on one hand connect the old parts of the city with new ones, and on the other, allows to increase density and to intensify the level of activities. This new space is intended for shared public activities. Using vistas and isovists, the student developed a parametric system that is concerned with possible walking scenarios. It connects the existing urban tissues with public buildings and towers at the west side of the site. First, the main pedestrian axes were connected to the building on the west, then, these were superimposed with preferred views measured by isovists from the key locations.



(a) Superposed photographs taken by the student along main walking route in the area.

(b) Three dimensional lines of sights processed from the route observations.



(c) Use of 3D isovist for defining primary gazes, building heights and building shapes.

Figure 3 - Project entitled "Design of negative space: isovist as a movement generator", author Havi Koslawsky.

This innovative methodology helped the student to create a new urban infrastructure that accumulates movement, strengthens the existing urban fabric and improves streetscape. It integrates, arranges and maintains all the visual elements of the street, including the road, adjoining buildings, sidewalks, street furniture, trees and open spaces, etc, that are combined to form the character of the city.

4. CONCLUSIONS

Integration of cognitive tools with parametric tools for simulation and optimization assisted students in developing the projects' organizational logic and in testing design options and iterations. Module's experience offers several pedagogical inputs to how new design skills and techniques, could contribute to expanding design methodology for architects and planners. Based on the outcomes of the module we draw conclusions for the further research-based design education that will bring together research and practice in computation, spatial analysis, spatial cognition and urban design. We also identify key issues, technologies and applications useful for adaptive, generative urban design.

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