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USING SPACE SYNTAX AS A TOOL FOR ARCHITECTURAL DESIGN

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ABSTRACT

Architectural design is a sophisticated process that advances from abstract thought to concrete design. In this process, the designed product is shaped and impacted by the unique experiences, observations, perceptions and characteristics of the designer, while the design work of the architects develops through the utilization of various design tools and the designer's own architectural knowledge, one that is fed from a variety of disciplines and fields. It is this scientific knowledge that directs the innate intuitions of the designer. This 'evidence-based design" approach is thus an attempt to bring science based knowledge into design.

This study focuses on the contribution of scientific knowledge in the architectural design process and explores the potentials and advantages provided by using space syntax as a tool in this complex design process. The aim of this work is intended to serve as a decoding of the invisible characteristics of space by focusing on the configurational theory of space.

To undertake this work, we established a three-staged design workshop as a means \ to evaluate the potentials of space syntax in the design process. Workshop participants (five architects and one interior designer) were given a design problem and this problem was examined during one-to-one meetings with the participants. Workshop participants were asked to design a living space for a specific site and with predetermined proportions. The workshop was divided into three stages. In the first stage the designer was asked to consider some issues related to life in a residence and the design of living spaces. In the second stage, the designer was asked to specify a set of home design relationships within a concept/action set, which includes residence-based activities (living, cooking, etc.), spaces (garden, balcony, etc.), measurable parameters (sound, light, etc.), and concepts (visibility, privacy, etc.). The third stage of the workshop focused on the space-making process. During this stage, the designers were expected to create a living space that reflected his/her design concepts. At the completion of these three stages, syntactic analyses were carried out on the designed spaces. In these analyses, the spatiality of the designer's preferences was explored and the potentials of designed spaces were discussed.

The findings of the study showed that space syntax succeeds in creating a link between science and design by transferring science-based knowledge into design process and produces graphical and mathematical data that the designer can use in testing his/her design proposals.

KEYWORDS

Architectural design process, design tools, design and science, space syntax

1. INTRODUCTION

Architectural design is the process of transforming abstract design ideas into physical spatial installations. Lawson tells us that the meanings inherent in the word "design" vary according to different career groups and its only common point is that it is a distinctive and complex activity (Lawson, 1997). For example, while scientists adopt a problem-oriented strategy during their development of a design process, architects adopt a strategy that is solution-oriented. Architects reflect the experience they gained in the construction of their design solutions. In architectural design, art, science and technical practice are intrinsically intertwined and serve as elements that are indispensable to architectural design. Utilizing such elements that differentiate architecture from other design domains and make it even more complex as a springboard for thinking and acting actually constitutes architecture that materializes while it is being fed from its scientific streams.

Vries and Wagter (1989) identified three problematic points in the architectural design process. The first issue is the fact that the number, order or timing of processes or tools used in every stage of design are open to change. The second is the fact that architectural design is open- rather than close-ended. The third is that architectural designs do not have a specific starting point. In this context, design is devoid of a clear sequence of phases that needs to be followed. The process thus becomes quite unique and exclusive to the designer. The originality of the architect and the world of suggested alternatives enable the architectural product to also be original.

The design process is a matter of synthesis of physical and mental behaviour. This process is also marked by the fact that it includes the kinds of physical and mental tools that mutually trigger and shape behaviour.

When we speak of an architectural design tool we are actually talking about a set of methods, tools, mechanisms, and apparatuses that assist in transforming the design idea from one mental state into another. The designer uses these tools in the thinking process and so such tools are not limited to the kinds of physical objects we used only while designing the ideas that were first conceived in our minds (Şişman, 2015). Another critical point is the fact that utilization of the defined tools or vessels is not hierarchical. And, as it is not hierarchical, any given tool can also be involved in a process more than once. The utilization of a tool depends on the uniqueness of the subject and how it is especially reflected onto the design product. Any tool may come into play based on the designer's wishes or the prerequisites inherent in the specific design, while it is also possible that while the tool is included in the design, its use is based on almost intuitive forces.

According to Hiller and Hanson, design is a process that moves from an unknown state into one that is known (Hiller and Hanson, 1997). Design tools mentioned here allow the production of information to be included in the design, along with thought processes during both the design process and the testing of the design solution. The tools used by the architect help the architect to gain access to information, transform it, and guide the design. This interaction between the tool and the designer is not unilateral, but is rather mutual and circular. This interaction is also mutually interacting and transforming.

In this sense, the architect becomes an actor who uses different goals and methods in the design process, integrating different sources of information, and thus enriching the design idea by transforming it. Not only does the personal view, character, intuitions, experience, and authenticity of the architect ensure that the architectural product will be original and free, the design process is also fed by theory, science, and research-oriented universal information.

In other words, architecture is a practice of "thinking by doing" led by data from different sources and different types of information in which intuition and science is brought together (Dursun, 2007). Information is required during each phase if this architectural product is to succeed in moving through design, production, and utilization phases, for it is information that leads the design, shapes the product, and is reproduced and reshaped for each design problem that rises during the process.

In the design process the architect is accompanied by his or her own architectural knowledge, and it is precisely this base of information that serves as the synthesis of practice and scientific theories. The intuition and reason that shape this body of knowledge and guide the architectural design process are locked into a dialectic relationship. According to Hiller and Hanson, design is the process of integrating intuition and reasoning (Hiller and Hanson, 1997). Scientific information that comes into play in the design process enlightens the designer and guides the designer's intuition. "Evidence-based design" is thus an example of utilizing scientific date in design (Şişman, 2015).

The architectural design process is a conscious activity, one that combines the mind, which is reason, and intuition, and does so in conjunction with each other. Aydınlı (2001) describes the relationship between intuition and reason as:

"Architectural training may impart two different categories of information packages, each in two different categories. While their desired relationships may be understood, the implementation of these two disparate sets may reflect certain challenges, challenges that lie in the kind of overlapping information acquired via reason or in information acquired via intuition. The designer has to decide how to maintain these two sets as they are intertwined, rather than allowing them to coexist simultaneously. In fact, immutable and rational information supports and enlivens the kind of information that flows from intuition and which is itself variable depending on the context." (Aydınlı, 2001).

A design that accords with scientific knowledge is stronger as it is supported by reliable sources. Evidence-based design is the term used for the common methodology that best enables scientific information to be transferred into design process. Hanson emphasizes that any socially responsible architectural design effort must be supported by evidence-based research (Hanson, 2001).

Post-occupancy evaluation represents an effort to analyse the true performance of a building after it has been put into use; such an evaluation, if it is conducted according to scientific principles, is a significant step as it provides valuable feedback to professionals about the design and also adds to a body of data that will aid the architect in the making of future design decisions. While this is true, we also have to point out that post-use evaluation efforts focus on the post design process, not the design process itself. Such an analysis does not evaluate the design per se, but rather the end-product utilization of the design itself.

Although the architect envisions the space as a living organism during the design process and uses his or her personal experiences to conceive of it in terms of human utilization, the designer has no real way of testing its human dimensions before the design is produced and utilized. In other words, even though physical representative tests may be conducted, and mental configurations construed during the design process, the end result is a construct that is built without human trial. It is at this confluence that the designer feels the need for methods and tools that will allow him or her to test the design suggestions (Şişman, 2015).

Because space syntax is a theory developed to reveal the kinds of spatial features hidden in spatial patterns, it has the aims of deciphering both the relational structure of the space and performing as an approach that includes scientific, digital and graphic-based methods (Hillier and Hanson, 1984; Hillier, 1996). It is precisely for these reasons that it has been chosen as the focus of our discussion. Hiller (2005) further expounded on space syntax by saying that models formed by this methodology reveal phenomenological dimensions about the space that can be scientifically tested and such models function as a bridge between humans and science based viewpoints. Space syntax with the theory and spatial measurement tools it presents allows us to delve not only into the visible but also allows us to uncover the kinds of hidden meanings that decipher the social meanings coded in that space. Another important aspect of space syntax is that it focuses both on human behaviour and the relational network of a meronymy (Kozikoğlu and Dursun, 2015).

Analyses of space syntax demonstrate that it can be used to analyse current spatial constructs in building and urban scale, and to test design suggestions (Dursun, 2007). Space syntax is very frequently used in building renewal processes during developing the design decision or restructuring public spaces in urban interventions (Şişman, 2015). In this study, the potential for using space syntax in the design process is discussed. This work also asks whether the above-mentioned approach can be used as a scientific design tool that feeds the design process by helping the designer to test the design suggestion.

2. DATASETS AND METHODS

This study evaluates workshop sessions held to shed light on the potentials of space syntax as a design tool that can be used from the first stages of design process onwards (Şişman, 2015). Analyses of this workshop set, which includes architect participants, focuses on questions as to whether space syntax has, or does not have, the potential to be used in architectural design through a design process based on a designated design problem. Thus, the study aims to investigate whether this approach can test the architect's own design through the numerical, comparable, tangible data this approach has produced and can help, or not help, the transfer of scientific information into the design.

In the conducting of the study, a designated workshop design problem is discussed with the participants through one-on-one interviews held with each designer. This design problem is specified as a living space design with both specific design concepts and located in a determined area. Instead of building a design for an imaginary parcel of land where the designer can determine all relationships, priorities and requests, the designer is asked to shape a living space in a specific area to test to what degree priorities can be reflected within the design. This area is specified as a 16 x 5 m parcel of land with two blind sides, one facade overlooking the sea, and the other facade onto the street.

The interviews with designers were held in three steps. The first step looked for answers to questions about the house itself, such as, "Which main concepts / components do you think life in this house is built on? What can you say about the concepts required in the design of this living space?" The answers were recorded for a limited time frame (5 minutes). The goal here is to obtain a description of the preferences and approaches established by the designer based on the individual characteristics and priorities of the designers prior to having received any guidance. This stage was transcribed so as to later reveal the designer's own words and emphasized concepts.

In the second step the designer was asked to determine the network structures he/she wanted to create within a set of concepts / actions (Figure 1). Current concepts / actions were listed as follows; (relationship with outdoor space; publicity; privacy; light; safety; compactness; depth; sound; hierarchy; visibility; accessibility; work; entertainment; balcony/terrace; eating; living; cleaning, garden; entrance; sleeping; circulation; cooking). The designer was allowed to intervene with the mentioned concept / action set; the designer could also inject new additions and suggestions into the given set. During this workshop step, the preferred "direct relationships" were determined by connecting the dots representing concepts / actions set placed on a sheet with the help of a rope. This investigation primarily revealed the structures similar to shaped networks, structures that had certain potentials in terms of specified concept, actions and relationships. Syntactic analysis was used to analyse these network-like structures created in accordance with concepts/actions during the entire workshop. How these deciphered potentials are transferred into the design and the designer's awareness of this process was discussed during the design stage.

The third step focused on the design practice. The network structures established in the previous step is expected to be reflected upon the design in this step. How the design of the house accords with the specified features of the building lot becomes significant at this step. The analysis also looked at the degree to which the designers' preferences were spatialized. During this step, a syntactic analysis was conducted on the designed spatial constructs so that the potentials of designed spaces could be established for discussion.

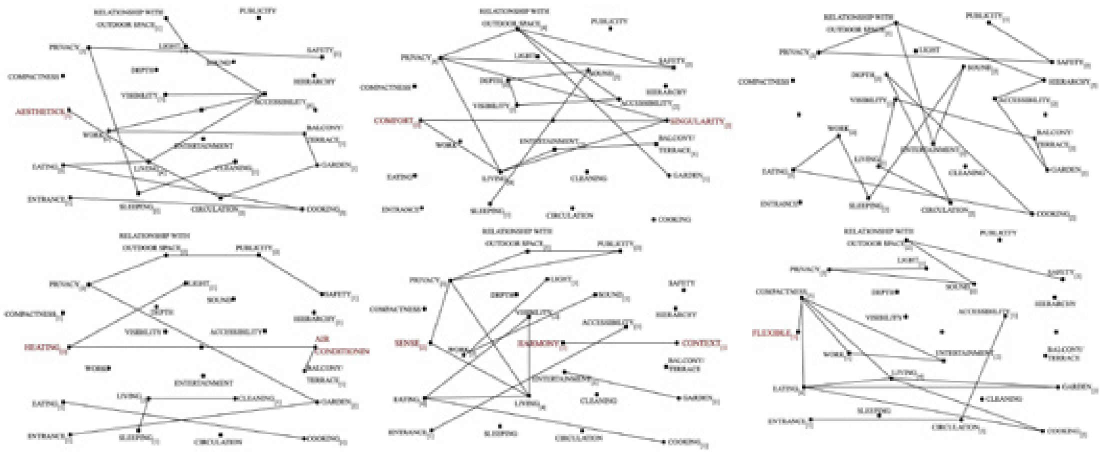

Figure 1 - Relationship Network Creations (red words are new additions)

As previously mentioned, a one-on-one interview was conducted as a chain of three steps. Six designers were interviewed during this workshop. The participants consisted of architects with academic and professional backgrounds and with an undergraduate or post graduate degree in architectural design / architecture, and post graduate students majoring in architectural design. Five of the designers have a background in architecture, and one in interior design.

At each step of the workshop, the focus of the data gathered and the analysis conducted were specific to the interviews. At the completion of all steps, the body of data from all interviews was evaluated and subjected to comparative and contrasting interpretations. The concepts and words emphasized by the designer that were revealed in the transcription of the interview held in the first step were identified as keywords, and in the second step network-like models defined through concept / action sets were analysed. Jass and Syntax 2D software were used for the syntactic analysis applied in the transcription of designed house. The spatial analysis applied on justified graphs was complemented by visibility graph analysis on isovist graphs. Figure 2 provides the plans for the living spaces designed in the workshop.

Figure 2 - Designed House Plans

The street was taken as the point of origin in the drawing of the justified graphs for the syntactic analysis to be applied to such spaces. Outdoor spaces such as entrance, front yard, back yard, terrace, and balcony are shown as convex spaces in the spatial construct to appear in the justified graph. Staircases are represented as convex space allowing transition between floors. Justified graphs show the in-depth values of the space (Figure 3).

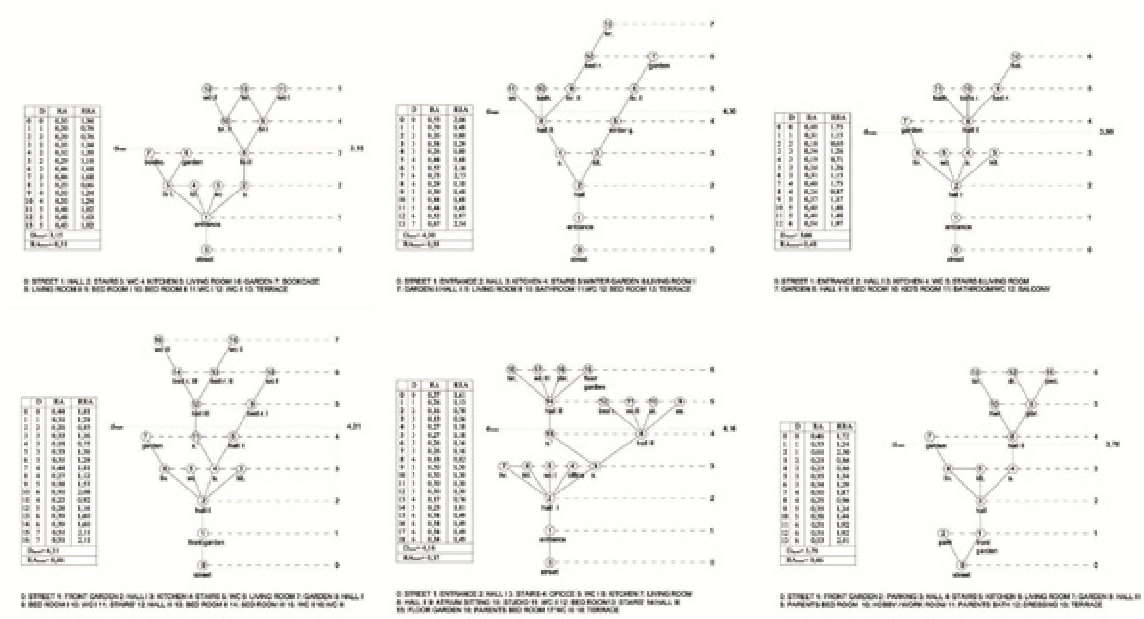

Figure 3 - Justified graphs of designed houses

Isovist graphs with inherited isovist integration values were established for each floor. The darkest red in the graphs represents the most visually integrated, in other words most visible spaces in the area, while the visual integration value decreases in the colour code moving from red to blue, which represents the least integrated spaces (Figure 4).

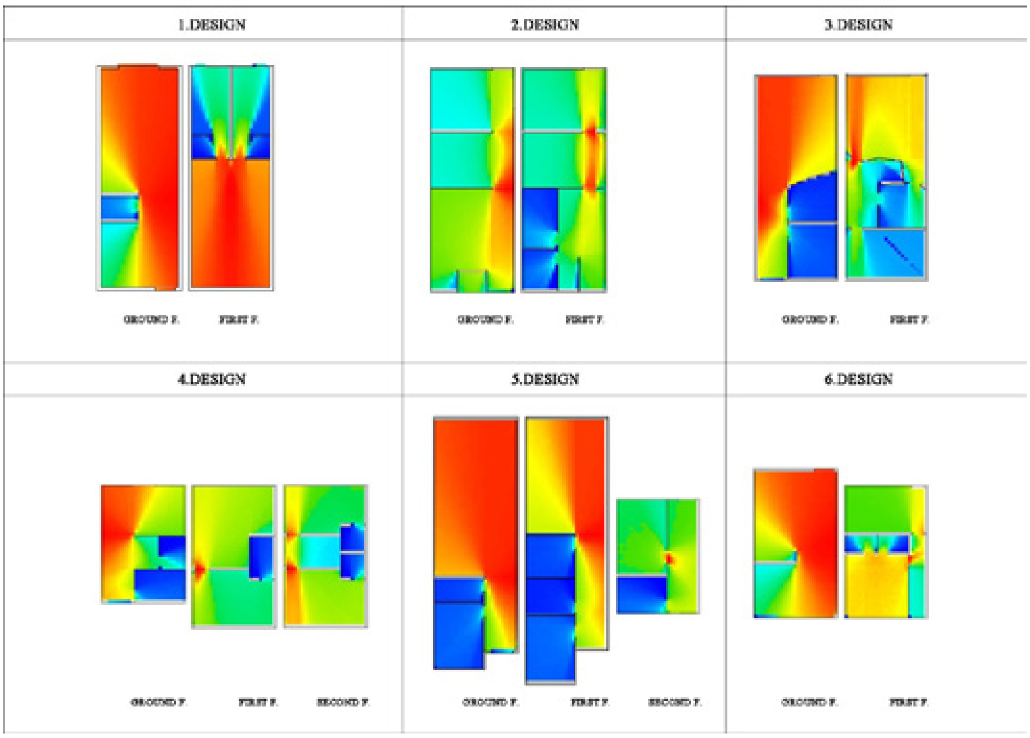

Figure 4 - Isovist visibility graphs of designed houses

The evaluation of the interviews procedures included superimposed interpretations of all stages:

1. Transcription of the designers' own verbal expression in the first step;
2. Establishment of network-like models defined through concept / action sets and their analyses in the second step;
3. Design of the houses and syntactic analyses run on the space in the third step.

3. RESULTS

This section includes a comparative evaluation of the data collected in three steps through the workshop.

Parameters emphasized throughout the verbal expression transcriptions in the first step are user-oriented; concepts such as an individual's needs, habits, activities and feelings, comfort / functionality etc. are emphasized to be significant in the interviews. While two designers emphasized occupancy rate (2nd and 6th designer) and privacy (5th and 6th designer), the designers independently also emphasized concepts such as aesthetics (1st designer) / space scenario (2nd designer) / ergonomics (3rd designer) / heating and insulation (4th designer) / harmony (5th designer) / flexibility (6th designer) / communication (6th designer) (Figure 5).

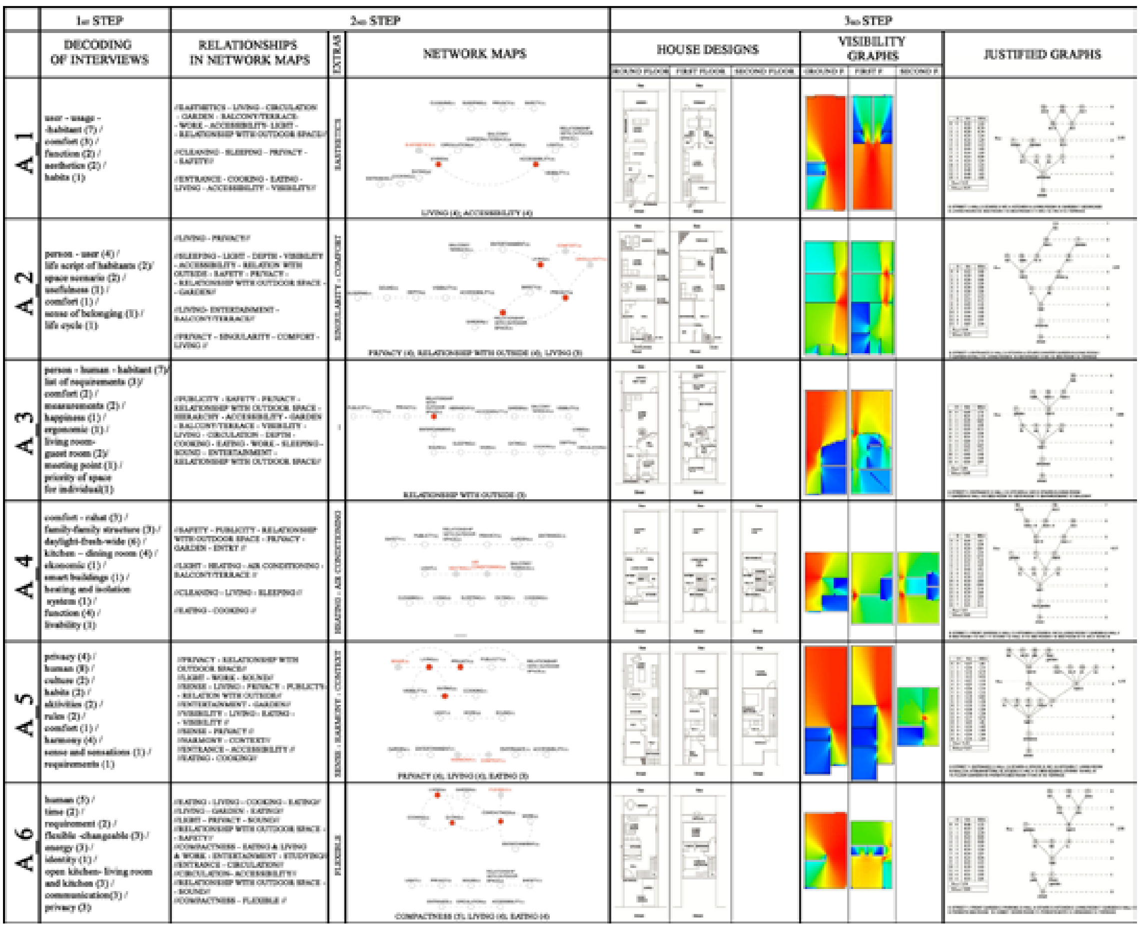

Figure 5 - Analysis of Total Data

In addition to the available components in the network structures determined in the second step, five designers added nine concepts (aesthetics / comfort-individuality / heating-ventilation / harmony-context-feeling / flexibility), while one designer built relationships between the given components without adding any other. As any one component has a higher number of connections in the network structures than the other components, it also gains prominence in the relational structure. These integrated (3-4-5 times connected) components / concepts (most integrated spatial concepts) in the network similar to spatial analysis lined up as follows;

1. Network table: living (4), accessibility (4);
2. Network table: relationship with outdoor space (4), privacy (4), living (3);
3. Network table: relationship with outdoor space (3);
4. Network table: (all connections have 2 and 1 connected concept/component);
5. Network table: privacy (4), living (4), eating (3);
6. Network table: compactness (5), eating (4), living (4).

'Living' can be interpreted as a significant common component as it has 4 connections in three network tables, 2 in two network tables, and 3 in one network table. This allows us to conclude that this concept is situated at the centre of the housing space. 'Privacy,' 'relationship with outdoor space,' and 'eating' are integrated components in two different network tables, while 'accessibility' in the 1st network table and 'compactness' in the 6th network table are particularly integrated components.

Examination of the plans of the designed houses in third step demonstrate that houses numbered 1,2,3 and 6 are designed to be two story, and houses numbered 4 and 5 are three-storied (Figure 5). As a larger percentage of the lot in houses numbered 1,2,3 and 5 are used as indoor space, the percentage of indoor and outdoor spaces in the whole lot in houses numbered 4 and 6 are quite similar. Outdoor space used in houses numbered 1, 2, 3 and 6 are shaped to be ground and balcony/terrace in the upper floor; only house number 4 has a ground level garden, while house 5 has a terrace and winter garden on the second floor.

An analysis of the syntactic data of the designed houses reveals that the maximum number of spaces in the house is 18 (house 5) while the minimum space number is 12 (house 3) (Table 1). The average number of spaces in these houses designed to be on the same lot is 14.16. The average ratio value of number of spaces to the number of spatial relationship as stated in the justified graphs is 0.95. If this value calculated by the ratio of the number of spaces over number of connections of the space is different than 1 it means that the particular house has a circular structure (Hiller and others 1987a). House 1 (0.86), house 5 (0.94) and house 6 (0/92) are the ones with circular structures creating alternative routes in the space.

As seen in Table 1, the depth values in the designed houses vary between 5 and 7. Justified graphs are created by including outdoor spaces into the system as a convex space and enabling the connection between floors through stairs. As the street is taken to be the origin, accessibility is analysed when outdoor space is included in the house, depth and integration values are also analysed.

House Number	Number of Space	Space / Link	Depth		Integration (RA)			Visibility Integration	
			Mean	Max	Mean	Max	Min	Max	Min
1	13	0,86	3,15	5	0,35	0,48	0,20	562112,9	14949,3
2	13	1	4,30	7	0,55	0,73	0,26	497621,2	49221,0
3	12	1	3,66	6	0,48	0,54	0,18	416707,7	50598,2
4	16	1	4,31	7	0,44	0,51	0,18	345300,1	21458,3
5	18	0,94	4,16	6	0,37	0,34	0,13	591170,6	39888,2
6	13	0,92	3,76	6	0,46	0,61	0,23	395414,1	19800,6
Mean	14,16	0,95	3,89	6,16	0,47	0,54	0,20	468054,43	32652,6

Table 1 - Syntactic data of the designed houses

The average integration values of the houses (RA) vary between 0.35 and 0.55. House 1 with the nearest average integration value to '0' is seen to be the most integrated house and house 2 with the nearest integration value to '1' is seen to be the most dissociated house.

House	Integration Value for Each Space (RA)
1	hall (0,20) = stairs (0,20) < living room II (0,23) < living room (0,29) < kitchen (0,32) < bedroom I (0,33) = bedroom II (0,33) < **mean integration value = 0,35** = street (0,35) = wc (0,35) < terrace (0,43) < garden (0,44) = bookcase (0,44) < wc I (0,48) = wc II (0,48)
2	hall (0,26) = stairs (0,26) < hall II (0,29) < kitchen (0,34) < entrance (0,39) = living room II (0,39) < winter garden (0,44) < bathroom (0,44) = wc (0,44) < bedroom (0,52) < **mean integration value=0,55** = street (0,55) < living room I (0,57) < terrace (0,67) < garden (0,73)
3	hall I (0,18) < stairs (0,19) < hall II (0,24) < entrance (0,31) = living room (0,31) < kitchen (0,34) = wc (0,34) < bedroom (0,37) < kid's room (0,40) = bathroom/wc (0,40) < **mean integration value = 0,48** = street (0,48) = garden (0,48) < balcony (0,54)
4	stairs (0,18) < hall I (0,20) < stairs' (0,22) < hall II (0,27) < hall III (0,28) < front garden (0,31) = living room (0,31) < kitchen (0,33) = wc (0,33) < bedroom I (0,38) < bedroom II (0,39) = bedroom III (0,39) < **mean integration value = 0,44** = street (0,44) = garden (0,44) < wc I (0,50) < wc II (0,51) = wc III (0,51)
5	stairs (0,13) < hall I (0,16) < stairs' (0,17) < hall II (0,18) < hall III (0,23) < entrance (0,26) = kitchen (0,26) = living room (0,26) < office (0,27) = wc I (0,27) < atrium sitting (0,30) = studio (0,30) = wc II (0,30) = bedroom (0,30) < floor garden (0,34) = parent bedroom (0,34) = wc III (0,34) = terrace (0,34) < **mean integration value = 0,37** = street (0,37)
6	hall (0,23) = stairs (0,23) < hall II (0,25) < front garden (0,33) < living room (0,34) < kitchen (0,35) = parent bedroom (0,35) < hobby/workroom (0,38) < **mean integration value = 0,46** = street (0,46) < garden (0,50) < parent wc (0,51) = dressing room (0,51) < terrace (0,53) < park (0,61)

Table 2 - Integration ranking order of the spaces in designed houses

The visibility graph analysis of the designed houses shows the following results for integration values: As House 1 has the highest, ground-level entrance hall, its lowest is in the WCs on the upper floor. In House 2 passage axes have the highest values bathroom and WC on the upper floor have the lowest. In house 3, as the connection between ground level entrance hall and living space has the highest value, it is reduced to the lowest in the kitchen and the WC on ground level. In house 4 the value is the highest in the ground level eating section, while it is the lowest in the kitchen and WCs. In house 5 the value is the highest in the ground level living space, the office and the WC, the bedroom workshop and WC on the upper floor and the WC on the second floor have the lowest values. In house 6 the value is the highest at the connection point of hall-living space-garden on ground level while the master WC and dressing room are the spaces with the lowest values.

Integration value ranking for the accessibility of designed houses can be seen in Table 2. Generally, halls and staircases appear to be the integrated spaces with low values as the spaces that have access to such spaces seem to have integration values lower than the average. Spaces with higher depths that are accessed directly rather than through passage points such as the garden, balcony, terrace and WCs are located in the bedrooms appear to be most dissociated spaces having values.

The intent of the first design is to achieve a design that is user-centred and focuses on such concepts of aesthetics and comfort that emphasize life and accessibility. The syntactic analysis of this design reveals that life and visible accessibility are achieved in the ground and upper floors. The designer, whose intent is to locate such activities as sleeping and personal hygiene in private and secure spaces has located these spaces in the deepest areas, thus achieving the goals set. The intent of the second design is to achieve a user-centred design focusing on space scenario, individuality and comfort so as to emphasize privacy and user relationship with outdoor space and living. The syntactic analysis reveals that the attempt was to achieve privacy via passage between spaces. The intent of the third design is to create a design that focuses on ergonomics, living space, user and user's needs so as to emphasize the relationship with outdoor space. The most integrated space in the isovist visibility graphs visually is the living space. The designer, who associates outdoor space with privacy, fulfilled this intention by choosing the deepest areas for the outdoor space. The intent of the fourth design is to create a design focusing on comfort, spaciousness and functionality so as to emphasize heating and ventilation. While the first and second steps demonstrated an emphasis on the relationship between eating and cooking, the visual integration values of locations chosen by the designer for these actions differ from each other and these spaces are located far from each other. This contradiction leads us to acknowledge that the designer could not achieve his/her goal. The intent of the fifth design is to create a design focusing on such concepts as humans, privacy, habits, feeling, harmony and context so as to emphasize privacy, living and eating. Stairs used at the entrance increased depth providing privacy between the street and the house. The positioning of the outdoor spaces on the top floor of the three-story building, in other words in the deepest locations dissociated from the system, can also mean that privacy is achieved in the indoor space construct. The relationships between eating, living, and cooking are observed to be integrated visually with outdoor space construct. The intent of the sixth design is to create a design focusing on humans, flexibility, communication and privacy so as to emphasize such components as compactness, eating and living. The concept of privacy is reflected on the design in the indoor space through the front yard design being between the street and the house and outdoor spaces positioned in higher depth locations. On the other hand, the food preparation, eating and living areas are designed as an open space, making this area one of the most integrated spaces in the whole, as the visibility graphs reveal. This shows that the intended communication is reflected onto the design.

4. CONCLUSIONS

This study has been conducted to investigate the usability of space syntax as a design tool methodology when included in the design process. Beyond deciphering the potential of construct designed in late stages of the design process, the potential of space syntax to be used as a tool in the first stages of the design is studied experimentally.

During interviews held during the workshop, architects were asked how they tested their designs. Designers' methods to test their products include testing them through experience and knowledge, imagining, modelling and consulting others' views as critiques. According to the given answers it is possible to say that design is tested primarily through intuition. Time constraints meant both that the designers could not be introduced to space syntax theory and its concepts, nor could they be allowed them to use such tools during the workshop. Syntactic reading/analysis on designed products by the authors reveal that space syntax methods offer significant potentials for the designers enabling them to comprehend the relationships between their goals and their designs, test their designs, predict the possible results of their design suggestions and comment on the spatial construct through numerical, scientific data on designed spaces. Undoubtedly, conveying the mentioned data to the designer during early stages of the design will contribute to the development of the architectural product. In this sense, it seems valuable and possible from the early stages of the design onwards to include evidence-based, concrete, scientific, universal information into the design process by valorising it as an intellectual tool that can guide architects' intuitions.

The analyses and space syntax evaluations allow us to unequivocally state that space syntax:

- Functions as a connection between science and design allowing scientific information to be transferred into the design process.
- Produces numerical, scientific data that allows the architect to test spatial constructs shaped showing the architect possible results of the design decisions made.
- Has potential to be a design tool that can be used in earlier stages of design.

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