Syntactic analysis and evaluation on different primary school buildings in Turkey

[Hatice Derya Arslan and Bilgehan Yılmaz Çakmak]

Abstract— **In this study, spatial relatedness of three different primary school projects (I, L and E type projects) applied throughout Turkey were analyzed mathematically with the method of space syntax. With graph theory methodology, spatial structure of primary schools obtained and compared with each other according to connectivity degrees and spatial structures. As a result of comparisons, the integration, connectivity and mean depth values of the classrooms, social spaces and lecturer rooms have been analyzed. For obtaining the comparisons, syntactical analyses have been done and justified graph maps have been analyzed. These maps have drawn with software of space syntax methodology named "Depthmap". According to study, the perceptibility and readability of primary school building project which has selected in three different types (I, L and E) can easily be detected by using space syntax method. As a result of syntactic analyses I type project showed the most satisfactory results in all cases investigated. I type project has been preferred by Turkish Government to the other projects, L and E. The results showed that, the method's testing is a powerful tool for evaluation of the existing educations buildings.** *(Abstract)*

Keywords— **Education, primary school buildings, primary school project, space syntax**

I.   Introduction

Education; is a process for the human to be transformed into social, political, economic and individually analyzed and improved. The most important function of education being the most substantial tool for the development of countries is to enhance the creative power and efficiency of the society by providing the ability – based development facility to the persons. In the Republic of Turkey, updates have been happening with the term and function of compulsory education system within the framework of cohesion process to European Union. The physical environments and facilities are among the determinant factors in the adaptation of students and teachers to the process of such adaptation.

The type – project applications have been widely employed for the architectural unity and rapid production of the buildings where the public and the similar official institutions here of would provide service across the Republic of Turkey.

The education structures used for the primary education, particularly for the mandatory education have been produced

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through type – project applications designed to be the most widely used public buildings within a short period of time in order to satisfy the need. By being adapted to the scope of changing educational term with modifications, the type – project applications are maintained to be used. Various studies addressing to overall problems encountered in type – project applications of the educational buildings in the Republic of Turkey have been achieved. The type – project applications and issues at the educational buildings have been addressed to in the studies [1-3].

While evaluation of the architectural project is being scrutinized over the plan in the stage of design under the title of building planning, as for the assessment of the structure at the stage of usage is being carried out under the title of its process of use. Both methods are also an assessment method applied for the purpose of augmenting user satisfaction. Particularly in recent years, distinct analysis methods have been employed to be able to perform the building assessments more practically and fasted in a computer – aided medium. As for the most popular one of these methods is the space syntax method.

There are studies where space syntax method was utilized for different building groups. For example; utilizing this method [4] has carried out the social evaluation for the museums, for the residences, for hospital buildings and for the shopping centers [5-7]. In the studies, it is seen that the method was also employed together with different comparative methods such as surveys, informative maps and visual simulation as well as the studies where solely the space syntax method was used alone [8-9]. It stands out that the spatial researched accomplished on the primary education buildings and type – project applications of these buildings are numerous [2, 3, 10] however, no assessment was ever made for the space syntax method – related educational buildings.

In the Republic of Turkey possessing a young and dynamic population, the changes in the term and function of compulsory education system within the framework of cohesion process to European Union necessitates a constant updating in the educational structures. In this context, all kinds of primary educational buildings – related spatial evaluation to be realized is quite significant. The space syntax method previously never used for assessment of the primary educational buildings piques with the researchers at the point of testing the achievement of this method from the primary educational buildings.

In this study, the primary educational buildings projected as to have three distinct types of projects (I, L and E) planned in different years and still in use have been evaluated by the space syntax method. In process of such evaluation, the comparisons have been realized for the visual integration, connectivity and depth concepts. The backbone of this study is

to determine a perceptible and readable building type for the primary educational building among three types – projects selected using the space syntax method. Giving insight to the designer has been intended to be conferred for the new projects to be drawn up by bringing in project design – oriented recommendations at the end of the study.

II. Education system and primary educational buildings in the Republic of Turkey

The most significant development within the scope of educational policies determined across the Republic of Turkey has realized upon increasing the compulsory educational term which used to be 5 years in the Republic of Turkey up to 8 years in 1998. The short fall of school building which became an agenda item upon transition to the new system was tried to be closed with an intensive schooling effort to the extent of facilities. In this process, intensive production of the type – project whose applications have been ongoing, being accompanied with its debates lasted for long years in the Republic of Turkey due to lack of time, element and financing – induced issues as well as difficulty of producing a separate project as per school building to be constructed has become an agenda item. Construction of school buildings tried to be speedily increased has happened by constructing a new building on a new lot and making a new building upon having demolished old structure available on a lot and additional floor construction above former building on the existing lot or a supplementary premises adjacent to existing building.

The transition to 12 year – compulsory education system (4+4+4) which was commenced to be implemented during 2012 – 2013 academic year, the debates of which have been still ongoing on its various dimensions prior to completely elimination of its physical and spatial shortfalls tried to be completely finalized with the return of the new educational system has been realized. Number of students increased as a result of lowering the school age to younger ages in comparison to former period and the requirements of user group whose age was made younger in this educational system are tried to be resolved by provisional applications. The spatial requirements revealed during commencement of 8 – year education program while existence of unsolved spatial issues from 5 – year primary education buildings [11] are tried to be fulfilled with limited modifications made and it has been observed that this need has relatively descended following new buildings are put into service over time. Nevertheless, it has been sighted that these obligatory transformations made in the primary educational buildings have usually resulted in limitation of extracurricular requirements of students. For example; [3,12] have identified that the spaces such as labs, library, and sports halls from the schools which were deprived from outdoor areas due to construction of new classrooms in the gardens of many primary educational buildings were converted into classrooms. Once the status of these structures found to be pedagogically problematic by the educational

scholars is considered from the perspective of different socio – economical structure between provinces and rural areas, it plays an active role in realization of personal gains during the primary educational period occupying a special importance in the human life. It is an ongoing issue debated regarding at what ratio the varying requirements of educational system were met by the buildings designed and arranged in line with the distinctive requirements of educational system as well as the conclusions produced via observation. Within the extent of the study, the assessment of primary educational building enjoying three different types – projects shall be carried out by the space syntax method.

III. Methodology

Syntax is defined as simple but basically different spatial arrangements required for the production of a set of rules. Space Syntax is a theory and method, used in order to define structural environments. The theoretical base of method has emerged with the thesis that "there is a relation between forms produced by external affects and numerical powers" [13].

A. Space Syntax in Architecture

Space Syntax contributes to a better understanding of interaction between design features, intended purpose of the formal possibilities and social contains. Space syntax is described as a whole of techniques to explain the spatial formation and classification of buildings and residential areas. Space Syntax reveals that must be understood the necessity of the rules and limitations to produce spatial forms. Method is also used to predict, evaluate and investigate the effects of various design alternatives. In recent years this method has been used to measure and define the readability through the eye of user and design styles. Space syntax tries to explain all the relations between the data of physical forms that observed by persons acting in space. These relations are between surface, edge and road data with each other and with whole system. In this study, for comparing layout scheme and spatial analysis of primary schools, Space Syntax method was used. Method is one of the analysis methods that included in morphological analysis techniques. Space syntax method can be called as a schematic presentation, which defines the changes in student behaviors, education methodology, user circulation and user differences [5].

Method is also used to investigate, predict, and evaluate the effects of various design alternatives. Nowadays, it is used to measure the intelligibility of the user or designer's perspective with the building's design styles [14].The most important feature of Space Syntax is, being a numerical technique which has capable of analyzing the abstract characteristics of space as a concrete characteristic. These have a critical role in the formation of knowledge based on the experiences which can be named as a reflection of space in human mind. The general idea of this method is that, by separating the parts of place that these are "the starting point of human experience", and bringing these pieces into maps or graphs to allow them to make quantitative analysis [13].There are some specific concepts in space syntax methodology.

Explanation of these concepts is important to interpret the results of analysis correctly and to understand the logic of the method.

Depthmap is a single software platform to perform a set of spatial network analyses designed to understand social processes within the built environment. It works at a variety of scales from building through small urban to whole cities or states. At each scale, the aim of the software is to produce a map of open space elements, connect them via some relationship (for example, indivisibility or overlap) and then perform graph analysis of the resulting network (Fig.1).
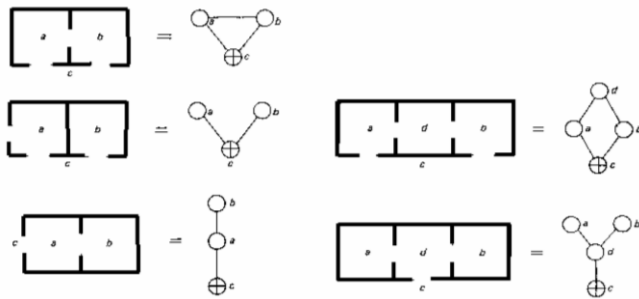

Figure 1.   Interior and external space connection in space organization and its expression with graphs [13].

The objective of the analysis is to derive variables which may have social or experiential significance 3 key concepts within the scope of the study will be considered for the interpretation of analyzes. These are connectivity value, visual integration value and visual mean depth [15]. Connectivity is measuring of the number of directly connected adjacent spaces. A local distance that measures the number of steps is away from each line [15]. This local criterion is the most basic knowledge about understanding space. The most important criterion to predict the movement of a movement along the line is the value of spatial integration (called as Visual Integration). Integration as a global benchmark is the average depth of the space to other spaces within the system. The relationship between the integration value and connectivity value is intelligibility or readability. If connected spaces are also integrated spaces, it means strong and intelligent spatial relation. In this case, all the components that make up the system itself are readable [13].

One of the most important relations in syntax method is the concept of spatial depth. Depth occurs when there is more than one crossing space to reach a space. If there is a low value to be reached in the deflection space, the depth is "shallow", if there is a high value; the depth is "deep". The important subject in this case is, showing as a value of the relation of each space with other spaces. This refers to the mean value of the whole, and allows for comparison with other systems [16].

IV.   Case Study

In this study three different types (called as I, L and E, hereafter) of primary school projects which have been designed in different years and still using, are selected. It has paid attention to the buildings which has built in different years, has got different class capacity and floor plan type. The selected projects are not known that in what ratio they represent the primary school buildings in Turkey. In the study three different project's ground floor plan are analyzed by each other with space syntax in Depthmap program by using visual integration, connectivity and depth concepts.

A.   *The General Properties of Projects*

I: It is 14 classes primary school project. It was designed in 5 years compulsory primary school system process and it continues education by additioning floor with the changes in education system. The project ground floor plan is about 550 m² and the building has two entrances. There are 7 classes at about 40 m^2, 1 teacher's room and toilets in flour plan.

L: It is 16 classes primary school project. It was designed in 5 years compulsory primary school system process and it continues education now. The project ground floor plan is about 670 m² and the building has two entrances. There are 4 classes at about 40 m^2, kindergarten classrooms - game room, management rooms and toilets in flour plan.

E: It is 32 classes primary school project. It was designed in 8 years compulsory primary school system process and it continues now. The project ground floor plan is about 1800 m² and the building has three entrances. There are 7 classes at about 50 m^2, kindergarten classrooms - game room, management rooms and toilets in flour plan.

B.   *The Space Analyzes of Projects*

Circulation scheme has a T-shaped form in the I (school with 7 classrooms) because of the opposite position of vertical circulation elements and entrances. As seen from Table 1, all plan schemes have not similar compositions with each other and also the increasing number of neighboring classes and teachers' rooms verify due to the changes in location of the rooms. The main entrances have not similar locations in I, L and E. Firstly justified graph are drowned with the Hillier and Hanson's space syntax theory for applying the method to selected project (Table 1). According to justified permeability graph scheme, every 3 primary schools have 3 steps transition. These are classified as entrances, circulation and classrooms The circulation schema is different in all types. I and L plans have two entrances, E plan has three entrances. It can be seen clearly in justified graphs that the most complicated plan schema is E plan and them most readable plan schema is I plan. Also the location of wet places is regular and together according to other plan schemas. After the preparations for analyzes necessary substructure has prepared for calculations. Justified Graph's point value at Table 1 is the number of the sides which comes from the point and it explains the entrance or emergence of the space. The depth space deep gives the value of last reached deep. The deep values of I, L and E are 2, 4 and 3, respectively. Maxpoint value is the value of the most emergence sides in depth graph.

Three different projects has analyzed by using space syntax in Depthmap program for the aspects of visual integration, connectivity and depth concepts. Three concepts are shown on Table 2 from ground floor plan comparatively.

TABLE 1. The analyses of spaces in the plans			
	I	L	E
CIRCULATION SCHEME			
PLAN SCHEME			
ENTRANCES			
JUSTIFIED GRAPH			

TABLE 2. Three key concepts in the plans			
	I	L	E
VISUAL INTEGRATION			
CONNECTIVITY			
VISUAL MEAN DEPTH			

According to analysis by space syntax in Depthmap program, the digital values (as minimum, average and maximum) which obtained with concepts are given in Fig. 2 for I plan scheme. Intelligibility / Readability relations for I plan is given in Fig.3. The average values for comparative on visual integration, connectivity and visual depth concepts are shown on Table 3 and maximum values are used to determine a perceptibility and readability on Table 4.

Attribute	Minimum	Average	Maximum
Connectivity	2	1283.57	3888
Point First Moment	40	894476	4.88504e+006
Point Second Moment	800	1.15108e+009	1.16079e+010
Visual Entropy	0	1.4004	1.98795
Visual Integration [HH]	1.71605	8.50925	203.421
Visual Integration [P-value]	0.682383	0.937858	52.1174
Visual Integration [Tekl]	0.803177	0.886817	4.55459
Visual Mean Depth	1	2.35907	5.363
Visual Node Count	4	10750.9	11935
Visual Relativised Entropy	1.8241	2.39719	3.99773

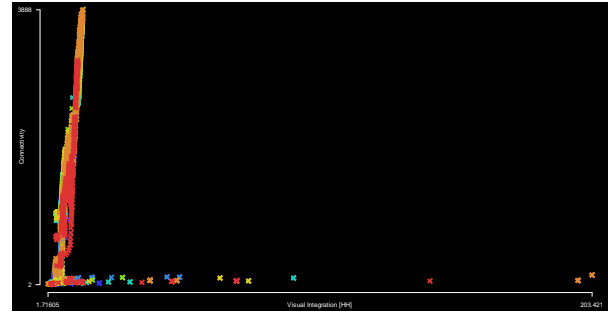Figure 2. Depthmap program output visual for I plan schema

Figure 3. Intelligibility / Readability relations for I plan

TABLE 3. Average values of three key concepts

	VISUAL INTEGRATION	CONNECTIVITY	VISUAL MEAN DEPTH
I	8.509	1283.57	2.359
L	5.412	734.428	3.073
E	5.145	1054.44	3.424

TABLE 4. Values of max connectivity, max Integration and max deapth

	I	L	E
max Integration	203	9.351	10.06
max connectivity	3888	2166	4005
max depth	5.363	4.835	5.955

V. Results and Evolutions

In this study only the plan schemas and using densities are analyzed. These findings are obtained from the results of compares for I, L and E plan schemas by space syntax analyzes.

As expected the obtained values from program are differ from each others. The causes of this condition are reviewed as follows;

- The clear definition of spatial neighborhoodness and relation with each other occurs by visual perception. In order to have less classrooms of L and E plan and the location of entrance and classrooms of I, this type of project is more readable than the others.
- Jointly located spaces according to their functions, supports the visual perception of the plans.
- Being positioned separately from the classrooms and teachers' room makes the system more readable in all plans.
- I plan schema is more readable and perceptible with regard to the location of classes, circulation scheme, the integration and connectivity degrees which are higher than L and E plans. The related values are given in Table 4.

- The visibility of entrances makes the system more readable and also increasing of entrance number reduces the mobility of the system by separating the integration and reduces the connectivity of system. This makes the system less readable and perceived (Table 1).
- When average visual integration, correlativity and depth values are checked, it's seen that the highest visual integrations and correlativity values are belonged to I plan diagram. This situation is clearly seen from the Table 4. According to the Table, the least depth degree is belonged to I plan diagram. Integration is the value which is used to sense the movement on the circulation line and when it's considered that the transition and depth of the areas inside the system give us the integration, it's seen that with the high value of integration, correlativity I plan diagram is the most perceptibility and readability of all.
- Perceptibility and readability of primary school building project which has selected in three different types can detect by using space syntax method.

Besides these results given above in bulletin format, in this some general inference can be done. Firstly, it is clear that, the results which are obtained from this study are limited with the plan schemas which are selected I, L and E. It's also possible that the method which has used in this study can be trying in different education buildings, the results which will be obtained by determining education buildings by following typological structure can be compare with the others. At the same time this method can be apply to buildings which has got different function and can be compare with the determining variable results.

In motion method is using usually for the existing building's space analyze. But it's possible that method can be tested while creating new designs before constructing the building. This method's testing will be useful for the revision projects of education buildings which must consider by the changing of educational system in Turkey especially.

Architectural design is not consisting only function analysis. In addition to perform technical and functional requirements, primary school building's child user's desires, emotions and perceptions should take into consideration and new primary school project should be design with the results which are obtained from mathematical models by supporting perceptional data's. It's seen as a weakness that there are quite limited studies in literature.

It's possible that the results which are obtained from space syntax can be compare with different methods. The results which are obtained from much approaching method's comparing is important and necessary to capture the not obtained or captured points with another method.

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