3D VISUALIZATION OF TRANSFORMATION IN HISTORIC TOWNSCAPE: CASE OF ZEYREK URBAN SITE

DR. T. KEREM KORAMAZ
Istanbul Technical University, Faculty of Architecure, Urban and Regional Planning Department, Taskisla, Taksim, 34437, Istanbul, Turkey
koramaz@itu.edu.tr

PROF.DR. NURAN ZEREN GÜLERSOY
Istanbul Technical University, Faculty of Architecure, Urban and Regional Planning Department, Taskisla, Taksim, 34437, Istanbul, Turkey
gulersoy@itu.edu.tr

ABSTRACT
Representation of the change in townscape is significantly important throughout the urban planning process in order to gain better comprehension regarding urban transformation. Then innovative visualization and representation tools may facilitate to accomplish this comprehension in third dimension. While recent conservation studies and interventions indicated a significant change in Zeyrek Urban Historic Area, motivation of this paper was based on the capability of two and three dimensional visualization techniques in definition of transformation in site's townscape. A questionnaire study was also conducted to gather the responses from the users, respectively graduate students in Faculty of Architecture, professions in planning and conservation institutions, high school students in the site as the representatives of inhabitants. As the fundamental finding of the study, it was concluded that the transformation in historic townscape was better defined in 3D urban model than 2D conventional mapping technique.

INTRODUCTION

Throughout the urban conservation process, analysis of townscape and physical environment of urban historic sites were significantly important to be examined in a detailed and comprehensive framework. For that reason urban conservation studies required utilization of three-dimensional (3D) representation techniques. Most common planning studies were developed with two-dimensional (2D) analysis, but such techniques may not be sufficient to evaluate townscape characteristics. This paper was held on a case study of the Zeyrek Urban Historic Site which was accomplished with definition of transformation in historic townscape by 2D and 3D visualization techniques. Visualization and representation techniques in the case study was then compared to determine the efficiency of these techniques with subjective responses from different interest groups in a questionnaire.
Townscape as the main theme of this paper was defined as physical environment that was perceived on the third dimension of urban space. Term of townscape expressed not only the actual composition of urban landscape, environment and sense of place but also the comprehensive definition of the change in the built environment (Burke, 1976 and Cullen, 1971). Representation of the change in townscape is significantly important throughout the urban planning process in order to gain better comprehension regarding urban transformation. Then innovative

visualization and representation tools may facilitate to accomplish this comprehension in transformation of urban historic sites.
3D urban models were defined as visualization techniques in urban design which provide efficient communication and visualize more spatial content and information than conventional 2D mapping techniques (Pietsch, 2000). CAD (computer aided design) software was conventionally utilized to generate 3D models as a last visualization tool in urban planning and conservation and mostly to evaluate the spatial characteristics of actual urban structure and design proposals (Bertol, 1997). Serving as a design tool, 3D urban models were powerful to show and evaluate the change in urban pattern (Al-Kodmany, 2002). Computer based 3D urban models were more prevailing tools to represent the real environment than the conventional visualization techniques

As the fundamental function of 3D urban models, communication and interaction function facilitated the participation and collaboration processes in urban planning and conservation. Therefore these models also developed learning skills (Hamilton et al., 2001) and cognition and perception abilities of users and stakeholders (Westerdahl et al., 2006). Then the efficiency of visualization techniques can be examined with the abilities of comprehension, cognition and evaluation processes of users and different interest groups in urban planning and conservation. This examination is necessary to improve the tasks of 3D urban models as an active communication tool integrated with definition of transformation in historic townscape.

The number of studies concerning the investigation of interest groups' responses for 3D visualization techniques in urban planning and architectural design process were increasing recently (Day, 2002). These investigation studies used various cognition measurement methods including how professions or non-professions described the virtual environment (Bates Brkljac, 2007; Neto, 2001; Westerdahl et al., 2006; Houtkamp and Oostendorp, 2007). In brief, 3D urban models were stated in these methodological studies, accurate and reliable 3D visualization techniques define more attributes in spatial content. These models improved the user's perception regarding the representation of physical and townscape characteristics and enhanced the communication and interaction of spatial information among user groups in order to develop urban planning and conservation applications in collaborative planning approach.

The purpose of this paper was to investigate the capability of visualization techniques, including 2D mapping technique and 3D urban model by comparing representation ability of transformation in historic townscape of Zeyrek Urban Site.
A questionnaire study was conducted to gather the responses from the different interest groups, respectively professions in planning and conservation institutions, graduate students and high school students in the site as the representatives of inhabitants. Users' responses were investigated and assessed in quantitative methods with descriptive statistics in order to measure how efficiently the transformation in historic townscape was perceived and comprehended by means of both visualization techniques.

TRANSFORMATION IN HISTORIC TOWNSCAPE OF ZEYREK URBAN HISTORIC SITE

Zeyrek is located north of the Historical Peninsula of Istanbul, on the slopes, viewing Golden Horn. As included in the World Heritage List, Zeyrek Urban Historic site was chosen as case area because of reflecting a variety of cultural structures in its urban space. The most important monument of the site is Mosque of Zeyrek which had been Monastery of Christ Pantokrator in the Byzantium Period (Figure 1). Zeyrek has a traditional organic pattern consisting of authentic, wooden, Turkish houses (Gülersoy-Zeren et al., 2001 and 2008) (Figure 2).

Figure 1. Mosque of Zeyrek and Zeyrekhane

Figure 2. Traditional wooden houses

METHODOLOGY

Transformation in historic townscape of Zeyrek Urban Historic Site was defined within the period between 1933 – 2008. The 1933 dated Pervititich Map had a special importance, because this map gave useful information related to urban pattern, built-up areas, unoccupied areas, road pattern, building materials and building heights in 1933 as the first stage in the period of transformation in Zeyrek Urban Historic Site (Figure 3).

This study also contained a number of urban survey analyses, carried out by a computer-based 3D urban model. Evaluation of three-dimensional effects throughout this study, was developed in order to indicate that urban conservation studies should be accomplished not only with the 2D mapping technique, but also with innovative 3D visualization techniques. The townscape analysis was generated in this study to investigate the structural form and relationships, visual quality, accessibility and harmony characteristics of the Zeyrek Urban Historic Site.

First inventory and registration studies for conservation of the Zeyrek Urban Historic Site, which were conducted by Istanbul (No.1) Board of Protection for Cultural and Natural Assets, were held in the period between 1977 - 1980. These inventory studies were prepared in order to establish registration framework for listed buildings to be included in urban conservation as civil and monumental architecture. Registration documents contained maps, photographs and detailed information regarding urban historic values of the sites and monuments (Istanbul No.1, Board of Protection for Cultural and Natural Assets, 1977) (Figure 4).

Figure 3. Zeyrek Urban Historic Site in Pervititich Map, 1933
Figure 4. Inventory Studies by Istanbul (No.1) Board of Protection for Cultural and Natural Assets in 1980

Survey and analyses, conducted in 2002, were updated by the help of onsite survey in 2008. The same survey and analyses were carried out with same titles as conventional analyses and townscape analyses. In the conventional analyses of Zeyrek Urban Historic Site, parameters were described in general consideration of urban analysis. These analyses can be conventionally generated in 2D mapping in most of the urban planning and conservation studies and projects. But each analysis was improved by having both visualization techniques; 2D mapping technique and 3D urban model. The conventional analyses of Zeyrek Urban Historic Site consisted of building use, building condition, building construction material, built and inbuilt-up areas, and listed buildings (Figure 5). Within the title of townscape analysis, relationship between each component's structural and visual characteristics, privacy and permeability levels in accordance with street pattern and appropriateness with traditional architectural characteristics were examined (Figure 6). Townscape analysis provided an evaluation method by developing computer based 3D urban model while this analysis indicated the buildings whether they preserve their traditional characteristics or not.

After urban survey and analyses, proposal for townscape in Zeyrek Urban Historic Site was prepared with both 2D mapping and 3D visualization techniques. While improving proposals for building forms, disharmonious structural additions were firstly cleaned in urban structure. Infill applications on building forms have been proposed as structural conditions and harmony with the urban pattern (Figure 7).
2D and 3D visualization techniques were compared regarding the representation ability of this transformation. A questionnaire study which was held in 2008 was conducted to gather the responses from the users, respectively graduate students in Faculty of Architecture, professions in planning and conservation institutions, high school students in the site as the representatives of inhabitants. Users' responses were investigated and assessed in quantitative methods with descriptive statistics in order to measure how efficiently the transformation in historic townscape was perceived and comprehended by means of both visualization techniques.

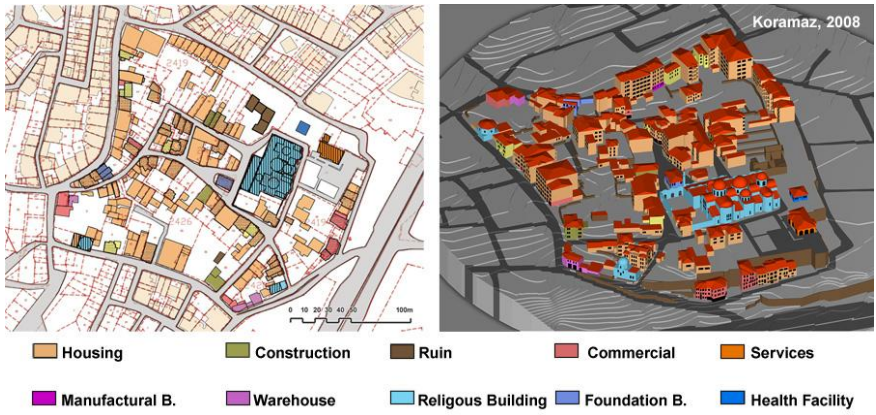

Figure 5. An example of conventional analysis: analysis of building use

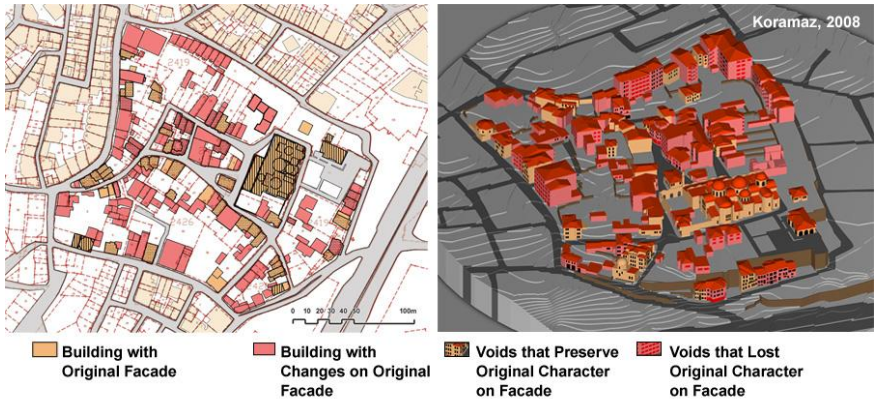

Figure 6. An example of townscape analysis: analysis of visual quality

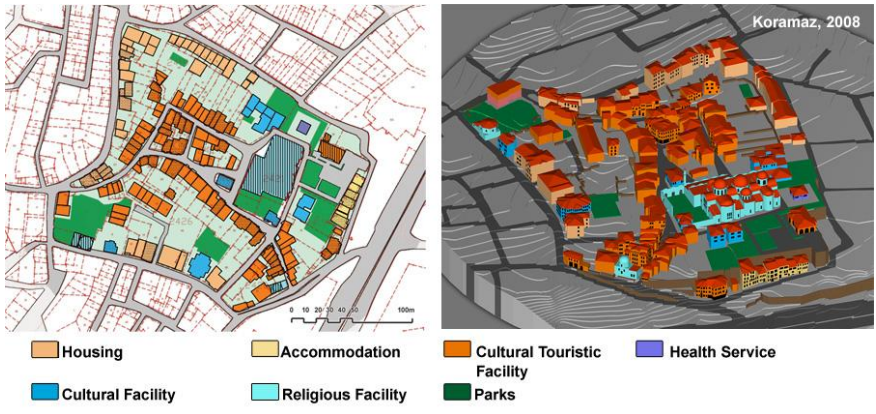

Figure 7. Proposal for townscape in Zeyrek urban historic site

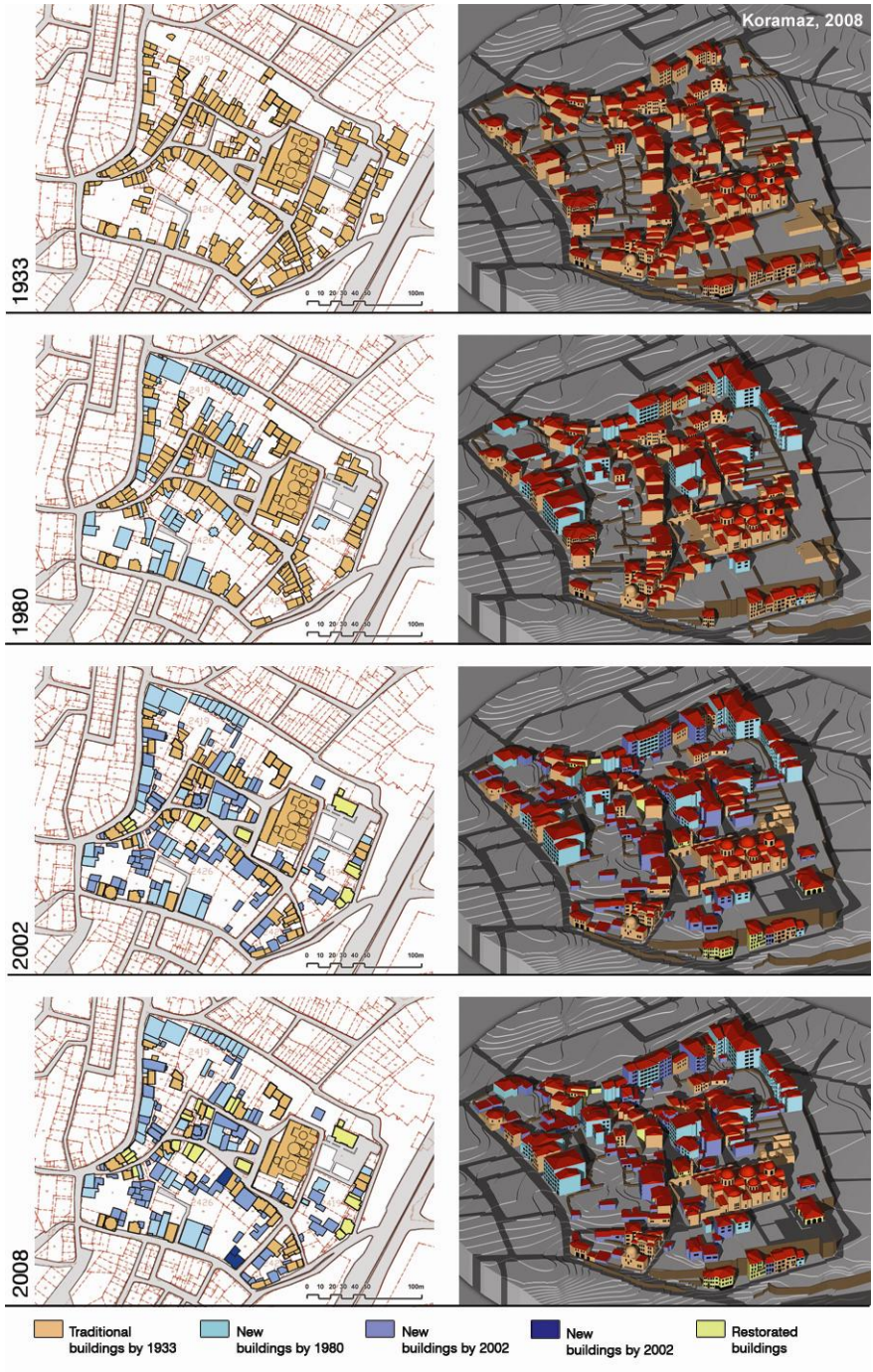

Figure 8. Transformation in historic townscape in Zeyrek urban historic site

Questionnaire mainly consisted of two sections as comprehension level of site characteristics in urban historic site and perception of historic environment. Each separate groups answered the same topics, covering the extent how they comprehend and perceive each figure and illustration and how they perceive the Zeyrek Urban Historic Site. All questions, in the number of 34 in the questionnaire were conducted in a seven level - likert scale with 1: "poor" and 7: "excellent". Within the purpose of this paper, responds for the questions related to transformation and cognition of townscape in historic environment were presented. These questions related to transformation and cognition of townscape are listed in Table 1.

Table 1. Definition of variables

Questions in the Survey	Codes	Variable Names
Part I. Comprehension level of townscape analyses *To what extent can…*		
1. analysis of structural condition define the site?	t_1	Structural condition
2. analysis of visual quality define the site?	t_2	Visual quality
3. analysis of accessibility and privacy define the site?	t_3	Accessibility and privacy
4. analysis of architectural harmony define the site?	t_4	Architectural harmony
Part II. Cognition level of historic environment *To what extent do you perceive…*		
5. sense of affection regarding quality in historic environment?	h_1	Sense of affection
6. historical evolution of the urban pattern?	h_2	Historical evolution
7. listed buildings in the site?	h_3	Listed buildings
Part III. Comprehension level of urban conservation project *To what extent can 2D or 3D visualization technique describe…*		
9 Zeyrek urban conservation project?	c_1	Conservation project
10. interventions in Zeyrek urban conservation study?	c_2	Conservation interventions

230 respondents in two groups involved in the questionnaire. 120 respondents in the professional group and 110 respondents in the non-professional group took part in the presentations and questionnaire study. Professional group consisted of graduate students in Istanbul Technical University, Faculty of Architecture and professions in planning and conservation institutions. Non-professional group consisted of students from two high schools, which were in the walking distance (500 m) to the Zeyrek Urban Historic Site.

Both of the questionnaires concerning the evaluation of users' responses for 2D and 3D visualization techniques were conducted after the presentations. Presentations and questionnaires were held in a meeting room in the faculty. Presentations were made by projecting the model and VR application to wall of the room. Respondents watched 10 minute - long presentation which consisted of the schemes and analysis, representing Zeyrek urban historic site. Then respondent groups filled the same questionnaire form in order to evaluate visualization technique which they have been presented.

The respondents' ages in the professional group ranged from 21 to 53 years, with an average of 28,19 years (S.D.=5.221, median 27). The respondents' ages in the non-professional group ranged from 14 to 19 years, with an average of 16,44 years (S.D.=1.026, median 17). Respondents assessed 2D mapping technique and 3D urban model in separate groups after separate presentations. As the first group 115 respondents evaluated 2D mapping technique in the experiment and as the second group 115 respondents evaluated the 3D urban model in the experiment.

In the professional group (n:120), 104 respondents (52 in the first group, 52 in the second group) stated they were using computer aided design software programs (AutoCAD, ArchiCAD, AllPlan etc). 42 respondents (20 in the first group, 22 in the second group) stated they were using GIS software programs (ArcGIS). 41 respondents (19 in the first group, 22 in the second group) stated that they were using 3D modeling software (3D Max, 3D Viz, etc). Between professional respondent groups, no statistically significant differences were found for the variables of education and computer experience.

RESULTS OF THE STUDY

Results from respondent groups were examined regarding to questionnaire form by means of statistical software package, SPSS 17.0©. Responses from professional and non-professional respondents, first and second groups, were compared with T-test to examine the equality of means. In the questionnaire 10 questions, which concerned the transformation and cognition of townscape in historic environment were asked. Firstly groups responded to what extent they comprehended townscape analyses, shown in the presentations. Then they respondend to what extent they perceived Zeyrek Urban Historic Site and finally urban conservation project with its proposals and interventions.

As the first group evaluated the presentation with 2D mapping technique and the second group evaluated 3D urban model, a comparison was assembled in order to measure the difference between these presentations in terms of delivering information for transformation of historic townscape in Zeyrek.
Overall, all of the mean values from second group were larger than the mean values from first group. However, T-test significance indicated that the statistically significant mean differences existed in all questions but in two questions in 90% confidence interval (Table 2).

Table 2. Comparison of 2D and 3D visualization techniques

Code	Variable Names	1. Group, 2D mapping n: 115		2. Group, 3D model n: 115		t	p.
		mean	s.d.	mean	s.d.		
t_1	Structural condition	5.16	1.19	**5.59**	1.02	-2.981	**0.00**
t_2	Visual quality	5.28	1.59	5.59	1.08	-1.747	0.08
t_3	Accessibility and privacy	5.10	1.70	5.43	1.13	-1.783	0.08
t_4	Architectural harmony	5.52	1.33	**5.93**	1.03	-2.607	**0.01**
h_1	Sense of affection	5.19	1.37	**5.72**	1.16	-3.171	**0.00**
h_2	Historical evolution	5.75	1.35	**6.17**	0.90	-2.761	**0.01**
h_3	Listed buildings	5.67	1.44	**6.02**	1.09	-2.067	**0.04**
c_1	Conservation project	5.12	1.43	**5.75**	1.02	-3.832	**0.00**
c_2	Conservation interventions	5.22	1.36	**5.57**	1.13	-2.111	**0.04**

Note: Question response format was seven-step scale from 1 to 7 and significant ($p<0.05$) highest mean values for each variable are printed in bold (s.d. = standard deviation, t = t statistics, p = significance values).

The group mean values from the second group, in the comprehension and cognition variables of structural condition (t_1), architectural harmony (t_4), sense of affection (h_1), historical evolution (h_2), listed buildings (h_3), conservation project (c_1), conservation interventions (c_2) were significantly (95% confidence interval) higher. But the other two variables of visual quality (t_2) and accessibility and privacy (t_3) were significant in 90% confidence interval (t_2; $p = 0.08$ and t_3; $p = 0.08$). As the most distinctive variables, sense of affection (h_1) and comprehension of conservation project (c_1) ($p = 0.000$; t values were in highest absolute values respectively as -3.171 and -3.832) were better determined by 3D urban model than by 2D mapping technique. The variable of historical evolution, (h_2) which referred to cognition of transformation in historic townscape (mean value = 5.75 in the first group and mean value = 6.17 in the second group) were also defined better in 3D urban model than in 2D mapping technique ($t = -2.761$; $p = 0.01$).

The figures briefly reported that 3D urban model delivered more information on the variables of both townscape characteristics and transformation in historic townscape of Zeyrek Urban Historic Site. Additionally, mean differences between responses from the entire groups were relatively sharp in the comprehension of structural condition, architectural harmony, sense of affection, historical evolution and conservation project in urban historic site.
Another comparison was assembled with the responses of professional and non-professional respondents. This comparison facilitated the planning and conservation professions and high school students' changing opinions and cognitions of transformation in historic townscape in Zeyrek. Table 3 represented the group mean values of variables by professions and Table 4 represented the group mean values by high school students referred to as non-profession group. Group mean values in Table 3 and 4 reported higher mean values in second group to which 3D urban model presented than in first group to which 2D mapping technique presented.

Table 3. Comparison of 2D and 3D visualization techniques by professions

Code	Variable Names	1. Group, 2D mapping n: 60		2. Group, 3D model n: 60		t	p.
		mean	s.d.	mean	s.d.		
t_1	Structural condition	5.00	1.22	**5.53**	1.03	-2.583	**0.01**
t_2	Visual quality	4.90	1.67	5.15	1.02	-0.987	0.33
t_3	Accessibility and privacy	4.72	1.87	5.15	1.15	-1.530	0.13
t_4	Architectural harmony	5.32	1.36	5.70	1.17	-1.656	0.10
h_1	Sense of affection	4.78	1.52	**5.40**	1.22	-2.448	**0.02**
h_2	Historical evolution	5.37	1.38	**6.07**	0.95	-3.236	**0.00**
h_3	Listed buildings	5.40	1.54	5.83	1.08	-1.785	0.08
c_1	Conservation project	4.37	1.29	**5.28**	0.92	-4.481	**0.00**
c_2	Conservation interventions	4.65	1.45	**5.15**	1.13	-2.107	**0.04**

Note: Question response format was seven-step scale from 1 to 7 and significant ($p<0.05$) highest mean values for each variable are printed in bold.

Table 4. Comparison of 2D and 3D visualization techniques by non-professions

Code	Variable Names	1. Group, 2D mapping n: 55		2. Group, 3D model n: 55		t	p.
		mean	s.d.	mean	s.d.		
t_1	Structural condition	5.33	1.14	5.65	1.00	-1.598	0.11
t_2	Visual quality	5.69	1.39	6.07	0.94	-1.691	0.09
t_3	Accessibility and privacy	5.51	1.39	5.75	1.04	-1.011	0.31
t_4	Architectural harmony	5.75	1.27	**6.18**	0.80	-2.165	**0.03**
h_1	Sense of affection	5.64	1.02	**6.07**	0.98	-2.284	**0.02**
h_2	Historical evolution	6.16	1.20	6.27	0.83	-0.556	0.58
h_3	Listed buildings	5.96	1.26	6.22	1.08	-1.135	0.26
c_1	Conservation project	5.95	1.08	6.25	0.87	-1.658	0.10
c_2	Conservation interventions	5.84	0.92	6.02	0.95	-1.019	0.31

Note: Question response format was seven-step scale from 1 to 7 and significant ($p<0.05$) highest mean values for each variable are printed in bold.

Profession group responses indicated a significant distinction between 2D mapping technique and 3D urban model based on the variables of sense of affection (h_1; $p = 0.02$), comprehension of structural condition (t_1; $p = 0.01$), historical evolution (h_2; $p = 0.00$), conservation project (c_1; $p = 0.00$), conservation interventions (c_2; $p = 0.04$). On the other hand, non-profession group responses indicated this significant distinction on two variables of architectural harmony (t_3; $p = 0.03$) and sense of affection (h_1; $p = 0.02$).

These results, based on changing responses from professions and non-professions, stated that, high school students, as the representatives of inhabitants, stressed only the sense of architectural harmony and affection. Architectural harmony which was associated with visual organization in urban and architectural pattern was evaluated in both 2D and 3D visualization techniques by the respondent groups. Non-professions had the ability to distinguish the abilities of 3D urban model in defining visual and historical relationship between each building unit on all distinct level of urban scale. Then

they highlighted the importance of abstract representation of buildings in 3D visualization technique whether they maintain visual and architectural vernacular characteristics.

On the other hand, professions stressed more variables defining the distinction of representation ability of 2D and 3D visualization techniques. As the major research topic of this paper, professions including graduate students indicated the variable of historic evolution was better defined with 3D urban model than 2D mapping technique. Additionally, responses from professions also reported that 3D urban model facilitated to represent conservation project and interventions to urban pattern. This is remarkable from the comparison between professional and non-professional groups that, professions stated the representation abilities of spatial content, including transformation in historic townscape and proposal characteristics in urban conservation project within the use of 3D urban model better than non-professional group. On the contrary, non-professional group were satisfied with the 3D urban model just because of improving perception and cognition of urban historic environment.

As the last investigation, all the variables were compared with regard to whether respondents had visited the site previously or not. A paired F-test was applied between newly formed three groups which were joint group as the all respondents who had visited the site previously, respondents who had not visited the site in 1. Group and 2. Group. Responses from the Joint Group supposed to be perception and cognition level of real environment.

Table 5 indicate the differences between cognition after the presentations, prepared by different visualization techniques and cognition after experiencing real environment. Within this comparison significant difference was only reported for sense of affection between Joint Group and respondents who had not visited the site in 1. Group. No significant difference was reported in between 2. Group and Joint Group. All other variables did not achieve any significant difference in representation ability of real environment. This mean that, respondents, who had not visited the site previously did not different cognition or preception from the Joint Group, who had visited the site previously.

Table 5. Comprehension level by respondent groups who visited the site previously or not

Code	Variable Names	Joint Group (JG) n: 120	Respondents, not visited the site in **1. Group 2D mapping n: 56**			Respondents, not visited the site in **2. Group 3D model n: 54**		
			mean	mean difference (JG- 2D)	p	mean	mean difference (JG- 3D)	p
t_1	Structural condition	5.40	5.21	0.19	0.57	5.48	-0.08	0.90
t_2	Visual quality	5.43	5.38	0.05	0.97	5.52	-0.09	0.91
t_3	Accessibility and privacy	5.23	5.18	0.05	0.97	5.43	-0.19	0.70
t_4	Architectural harmony	5.67	5.68	-0.01	1.00	5.91	-0.24	0.44
h_1	Sense of affection	5.64	5.11	**0,53**	**0.03**	5.41	0.23	0.50
h_2	Historical evolution	5.83	6.00	-0.18	0.62	6.20	-0.38	0.12
h_3	Listed buildings	5.83	5.77	0.07	0.95	5.94	-0.11	0.86
c_1	Conservation project	5.30	5.39	-0.09	0.89	5.78	-0.48	0.06
c_2	Conservation interventions	5.26	5.46	-0.21	0.57	5.61	-0.35	0.20

Note: Question response format was seven-step scale from 1 to 7, higher mean difference values ($p<0.05$) are printed in dark (Joint Group, JG: respondent group who visited the site previously).

CONCLUSION

In brief, 2D mapping technique was less capable of creating sense of affection in representation of historic townscape than 3D urban model. On the contrary, 3D urban model was more capable of representing townscape characteristics, including structural condition, visual quality and traditional listed buildings than 2D mapping technique. In accordance with the responses from planning and conservation professions, the most important skills of 3D urban models' are

- explanation ability of conservation project and interventions to structural and visual quality of urban historic environments,
- representation ability of transformation in historic townscape of urban environments,
- improvement of cognition and perception level of urban historic environment with the creation of affection sense.

As non-professional group, high school students shared on of the three skills of 3D urban model above. In accordance with high school students' sense of affection to urban historic environment, 3D urban model was efficient to represent the urban pattern whether it maintained architectural vernacular characteristics.

In summary, 3D urban model was reported to have given a fairly better representation of transformation in historic townscape of Zeyrek Urban Site than 2D mapping technique. The representation ability of 3D urban model was regarded as the improvement of both professional and non-professional groups' cognition with the sense of affection to urban historic environments. The methodology in this paper presented the capabilities of innovative 3D visualization techniques dedicated to put urban conservation projects into the services of various interest groups in planning process.

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