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Indagine sull'utilizzo delle tecniche di visualizzazione 2D e 3D che rappresentano il cambiamento del paesaggio urbano storico
Users' Responses to 2d and 3d Visualization Techniques, Representing the Change in The Historic Townscape

Al fine di descrivere il cambiamento del paesaggio urbano di siti riferiti alla città, gli strumenti moderni di visualizzazione possono essere utilizzati per aumentare le possibilità di rappresentazione, in misura maggiore rispetto ai metodi tradizionali. Studi recenti di conservazione ed interventi effettuati hanno indicato un cambiamento significativo nel paesaggio urbano storico di Zeyrek: questo articolo presenta le possibilità di rappresentazione insite nella tecnica di mappatura bidimensionale e nella realizzazione di un modello tridimensionale del comparto, utilizzati nella definizione del cambiamento del paesaggio urbano. Per valutare l'effettiva capacità di rappresentazione per mezzo di risposte da parte degli utenti dei modelli, è stato sottoposto un questionario agli studenti di laurea specialistica della Facoltà di Architettura, ai professionisti in enti di pianificazione e di conservazione ed agli studenti delle scuole superiori. A conclusione principale dello studio, si è compreso come il cambiamento del paesaggio urbano sia definito meglio nel modello urbano tridimensionale che nella tecnica di mappatura bidimensionale, in termini di rappresentazione dei dettagli architettonici e delle caratteristiche strutturali del luogo.

In order to represent change in the townscape of urban sites, innovative visualization tools may enhance more capabilities than conventional ones. While recent conservation studies and interventions indicated a significant change in the Zeyrek Urban Historic Site, the motivation for this paper came from the representative capability of 2D mapping techniques and 3D urban models to define the change in a townscape. A questionnaire was conducted to measure this capability by means of users' responses from graduate students in the Faculty of Architecture, professionals in planning and conservation institutions, and high school students. It was concluded that the changes in townscape was defined better than when familiar with the 2D mapping technique by the 3D urban model in terms of representation of architectural details and structural characteristics of the site.

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Throughout the urban conservation process, analysis of the townscape and physical environment of urban historic sites were significantly important enough to be examined in a detailed and comprehensive framework. For that reason urban conservation studies came to require the utilization of three-dimensional (3D) representation techniques. The most common planning studies were developed by familiar with two-dimensional (2D) analysis, but such techniques may not be sufficient to evaluate townscape characteristics. This paper was held during a case study of the Zeyrek Urban Historic Site which was accomplished with a definition of change 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 a physical environment that was perceived on the third dimension of urban space. Townscape, as a term, expressed not only the actual composition of urban landscape, environment and sense of place but also the comprehensive definition of the changes in the built environment (Burke, 1976 and Cullen, 1971). Representing change in the townscape has become significantly important throughout the urban planning process as a means to gain better comprehension regarding urban change. Innovative visualization and representation tools may also facilitate a comprehension in the changes experienced by urban historic sites.

3D urban models, which were defined as one of the visualization techniques in urban planning and design, have provided efficient communication and have allowed the visualization of more spatial content and information than the 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 design. This was mostly to evaluate the spatial characteristics of actual urban structure and design proposals

1. Mosque of Zeyrek and Zeyrekhane.

(Bertol, 1997). As a design tool, 3D urban models become a more powerful means to show and evaluate the change in urban pattern over time (Al-Kodmany, 2002). Computer based 3D urban models were more prevalent tools to represent the real environment, rather than the conventional visualization techniques

As the fundamental function of 3D urban models, namely 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 cognitive and perceptive abilities of users and stakeholders (Westerdahl et al., 2006). The efficiency of visualization techniques can be examined by the 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 townscapes.

The number of studies concerning the investigation of user groups' responses for 3D visualization techniques in urban planning and architectural design process have been increasing recently (Day, 2002). These investigative studies used various cognition measurement methods including how professionals and non-professionals described the virtual environment. Most of the studies which aimed to systematically describe the perceived environment mostly use a semantic (meaning) measurement scale (Bates Brkljac, 2007; Neto, 2001; Westerdahl et al., 2006; Houtkamp and Oostendorp, 2007). In brief, 3D urban models were stated in these methodological studies, as being accurate and reliable 3D visualiza-

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tion techniques that could 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 to develop urban planning and conservation applications in collaborative planning approach.
In describing how users experience their environment, the first semantic measurement scale study, by Osgood, Suci and Tannenbaum (1957), was titled "The Measurement of Meaning". Osgood and his colleagues asked respondents sets from a large number of adjectives to describe various context and terms. Then the seven-step scaled answers were factor-analysed to cluster these adjectives into seven dimensions as, evaluation, potency, activity, stability, tautness, novelty and receptivity.
As the second study, titled "A semantic model for describing perceived environment", written by Küller (1972) aimed to measure and describe the experiences of built environments systematically. Küller criticized Osgood, Suci and Tannenbaum's study as being limited in measuring the perception of built environments. In the semantic environmental scale (SMB from Swedish ''semantisk miljö beskrivning) Küller also used the same methodology to factor-analyze the seven-step scaled answers. However in this study, the respondents were asked to describe not the context or terms but the images from real environment and living spaces. To describe the experience of respondents in a built environment, Küller comprised eight dimensions or factors as pleasantness, complexity, unity, enclosedness, potency, social status, affection and originality.
In order to investigate the efficiency of 3D urban models, Osgood, Suci and Tannenbaum's semantic differential scale was mostly used to compare these techniques with functions such as, accuracy, realism and abstraction. But Küller's SMB scale attained a more favorable comparison with regard to what extent these techniques represented the real environment (Westerdahl et al., 2006). In addition, the SMB scale can efficiently be used in either built environments or representation tools and visualization techniques such as sketches, collages, 3D models, films or TV techniques (Küller, 1991). For all these reasons, SMB scale was chosen in this study to compare users' responses for 2D and 3D visualization techniques conducted as representations of the Zeyrek Urban Historic Site.

2. Traditional wooden house.


3. Traditional street view.

CHANGE IN HISTORIC TOWNSCAPE OF ZEYREK
This paper discussed the Zeyrek Urban Historic Site as the case area, with its change in historic townscape offering a means of comparing the efficiency of 2D mapping technique and the 3D urban model. Zeyrek is located north of the Historical Peninsula of Istanbul, on the slopes, viewing Golden Horn. As it is included on the World Heritage List, the Zeyrek Urban Historic Site was chosen as the case area because it reflects a variety of cultural structures in its urban space. The most important monument of the site is the Zeyrek Mosque which had been the Monastery of Christ Pantokrator during the Byzantine Period (Fig. 1). Zeyrek has a traditional organic pattern consisting of authentic, wooden, Turkish houses (Gülersoy et al., 2008) (Fig. 2 and 3).
The case study was mainly based on the Zeyrek Conservation Development Plan that was prepared by Gülersoy et. al. (2001). With the help of this plan, cultural monuments and the present townscape were documented by gathering facade plans, photographs, drawings, and other visual materials that are vitally important. Changes in the historic townscape of Zeyrek Urban Historic

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4. Zeyrek Urban Historic Site in Pervititich Map, 1933.

Site were defined within the period between 1933 – 2008. The 1933 Pervititich Map had a special importance, because this map gave useful information related to urban patterns, built-up areas, unoccupied areas, road patterns, building materials and building heights in 1933 which was first stage in the period of change in the Zeyrek Urban Historic Site (Fig. 4).

First inventory and registration studies for conservation of the Zeyrek Urban Historic Site, which were conducted by the Istanbul (No.1) Board of Protection for Cultural and Natural Assets, were held in the period between 1977 - 1980. These inventory studies were prepared to establish a 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 the urban historic values of the sites and monuments

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5. Inventory studies by Istanbul (No.1) Board of Protection for Cultural and Natural Assets in 1980.

(Istanbul No.1, Board of Protection for Cultural and Natural Assets, 1977) (Fig. 5).
Through the change in the historic townscape of Zeyrek Urban Historic Site, the third stage was based on the data, conducted from the master thesis "Three-Dimensional Evaluation in Urban Conservation Applications Based on Computer Aided Design" (Koramaz, 2002). This study contained a number of urban survey and analyses, conducted by computer based 3D urban model. The evaluation of three-dimensional effects throughout this study was developed in order to indicate that urban conservation studies could be accomplished not only with 2D mapping techniques, but also with innovative 3D visualization techniques. 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.
The last stage of the period for defining hi-

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storical change was 2008. The survey and analyses, conducted in 2002, were updated by the help of onsite survey in 2008 (Koramaz, 2009). The same survey and analyses were carried out with the same titles as conventional analyses and townscape analyses. In the conventional analyses of the Zeyrek Urban Historic Site, parameters were described in general consideration of urban analysis. These analyses were conventionally generated in 2D mapping in most of the urban planning and conservation studies and projects. However, each analysis was improved by having both visualization techniques; 2D mapping technique and 3D urban models such as building use, building condition, construction material, built and inbuilt-up areas, and listed buildings. Within the title of townscape analysis, the 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 also examined. Townscape analysis provided to be an effective evaluation method by developing a computer based 3D urban model, while these analyses indicated whether the buildings preserved their traditional characteristics or not. Changes in the historic townscape of Zeyrek were then defined with numbers in accordance with the documents and records from respectively 1933, 1980, 2002 and 2008 (Table 1). All the records, maps and photographs were overlapped with the recent up-to-date map, and buildings were investigated on the site. When we considered the changes in townscape, the most important shift was observed to occur during the 1980s when 81 traditional buildings were demolished. 196 buildings were documented in the 1933 Pervititich Map, but by 2008 there were only 44 buildings which had survived. Some of these buildings are presented in Figure 7. After 2000s, the site began to be restored. There were 7 traditional buildings in 2002 and additional 8 restoraed buildings in 2008. Some examples of restored buildings are shown in Figure 8. The Zeyrek Mosque had become a significant example of restoration project by 2010 (Fig. 1).

Type	Building Period	1933	1980	2002	2008
Traditional Buildings	Traditional buildings, demolished before 1980	81			
	Traditional buildings, demolished after 1980	46	46		
	Traditional buildings, demolished after 2002	10	10	10	
	Traditional buildings, survived from 1933 to 2008	59	59	52	44
	Total	**196**	**115**	**62**	**44**
Restored Buildings	Restored traditional buildings by 2002			7	7
	Restored traditional buildings by 2008				8
	Total			**7**	**15**
New Buildings	New buildings existent in only 1980 and demolished in this period		21		
	New buildings existent in the period between 1980 and 2002		1	1	
	New buildings constructed by 1980 and existent until 2008		37	37	37
	New buildings existent in only 2002 and demolished in this period			6	
	New buildings constructed by 2002 and existent until 2008			76	76
	New buildings constructed by 2008				2
	Total	**196**	**174**	**189**	**174**

Table 1. Number of traditional, restored and new buildings in the period between 1933 - 2008

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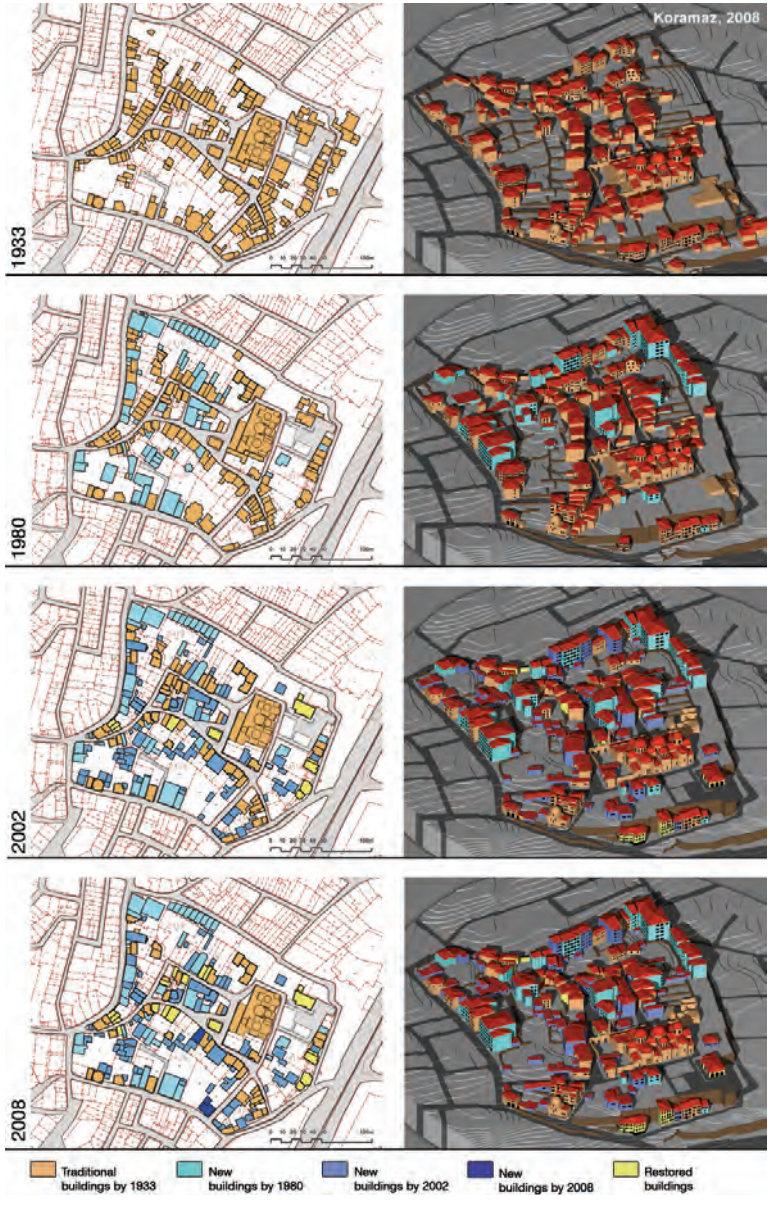
Analyses based on changes in the historic townscape were not only evaluated in numbers but also visualized firstly by 2D mapping technique, then by a 3D computer based urban model (Koramaz and Gülersoy, 2010) (Fig. 6). The computer that was used to produce 3D urban model and maps, was an Intel Centrino Duo that was running at 1,66 GHz ,contained 1 GB RAM and supported the GeForce 8400M GS. The 3D modeling of the existing townscape was generated by AutoCAD 2004©. By block modeling in the CAD system, a 3D urban model was transformed into the VRML format to produce an animated model to create for immersive virtual environment. According to the aim of this study, both 3D model and 2D mapping techniques constituted the base of survey studies in historic evolution of the site. Both the 2D mapping technique and the 3D model had the same physical elements which were formed with buildings, tombs and religious buildings as monumental buildings and finally streets.

METHODOLOGY

While recent conservation studies and interventions in the Zeyrek Urban Historic Site indicated a significant change in urban historic characteristics, the motivation for this paper came from the capability of 2D and 3D visualization techniques in definition of this change. These visualization techniques were 2D conventional mapping and a 3D urban model, generated by means of historic documents, images and inventories. A questionnaire study was held in 2008 to gather responses from users; respectively graduate students in thr Faculty of Architecture, professionals in planning and conservation institutions, and high school students in the site as the representatives of the inhabitants. The users' responses were investigated and assessed in quantitative methods with descriptive statistics in order to measure how efficiently the change in historic townscape was perceived and comprehended by means of both visualization techniques.
Questionnaire mainly consisted of three sections, the comprehension level of townscape analysis, the cognition level of the urban



6. Change in historic townscape in Zeyrek urban historic site (Koramaz and Gülersoy, 2010).

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7. Traditional buildings in historic townscape of Zeyrek Urban Historic Site.

historic environment, and the perception of semantic environmental scale components. Each separate group answered the same topics, covering the extent of how they comprehended and perceived each figure and illustration and how they perceived the site in the components of the SMB. All questions in the questionnaire were conducted in a seven-level Likert scale with 1: "poor" and 7: "excellent". Within the purpose of this paper, responses for the questions related to change and cognition of townscape in the historic environment were presented. The results of chosen questions listed below were mainly the ones related to change and the cognition of the historic townscape.

In the first section of the questionnaire, respondents were asked to describe their comprehension level for townscape analyses in the Zeyrek Urban Historic Site. While answering those questions, the related slide was presented to the respondents. The second section of the questionnaire was mainly based on the cognition level of the historic townscape. The third section described respondents' own perception level on the SMB components of pleasantness, complexity, unity, enclosedness, potency, social status, affection and originality (Table 2).

Both of the questionnaires concerning the evaluation of users' responses for 2D and 3D visualization techniques were conducted after the presentations. The presentations and questionnaires were held in a meeting room in the faculty. Presentations were made by projecting the presentations on a wall of the room. Respondents watched a 10 minute presentation which consisted of the schemes and analysis, representing the Zeyrek Urban Historic Site. Respondent groups the completed the same questionnaire forms in order to evaluate the visualization technique which had been presented.

230 respondents in two groups completed the questionnaire. 120 respondents in the professional group and 110 respondents in the non-professional group took part in the presentations and questionnaire study. The professional group consisted of graduate students in Istan-

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8. Restored buildings and urban façade in historic townscape of Zeyrek Urban Historic Site.

bul Technical University, Faculty of Architecture and professionals in planning and conservation institutions in Istanbul. The non-professional group consisted of students from two high schools, which were within walking distance (500 m) of the Zeyrek Urban Historic Site.
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).The respondents assessed the 2D mapping technique and the 3D urban model in separate groups after separate presentations. The first group of 115 respondents evaluated 2D mapping technique in the experiment and the second group of 115 respondents evaluated the 3D urban model in the experiment.
In the professional group (n:120), 104 respondents (52 in the first group, and 52 in the second group) stated they were familiar with computer aided design software programs (AutoCAD, ArchiCAD, AllPlan etc). 42 respondents (20 in the first group, and 22 in the second group) stated they were familiar with GIS software programs (ArcGIS). 41 respondents (19 in the first group, 22 in the second group) stated that they were familiar with 3D modeling software (3D Max, 3D Viz, etc). Between the professional respondent groups, no statistically significant differences were found for the variables of education and computer experience.

RESULTS

Results according to responses from respondent groups were examined regarding to questionnaire form by means of a statistical software package, SPSS 17.0©. Responses from the professional and non-professional respondents, and the first and second groups, were compared with a T-test to examine the equality of means. As the first group evaluated the presentation with the 2D mapping technique and the second group evaluated the 3D urban model, a comparison was assembled in order to measure the difference between these presentations in terms of delivering information for change in the historic townsca-

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pe in Zeyrek. Overall, all of the mean values from the second group were larger than the mean values from the first group. However, T-test significance indicated that the statistically significant mean differences existed in all except one questionand in three questions in the 90% confidence interval (Table 3).
The group mean values from the second group, in the comprehension and cognition variables of structural condition (t1), architectural harmony (t4), change in historic townscape (h1), listed buildings (h2), were significantly (95% confidence interval) higher. But the other two variables of visual quality (t2) and accessibility and privacy (t3) were significant at a 90% confidence interval (t2; p = 0.082 and t3; p = 0.076). As the most distinctive SMB components, sense of unity (s3), enclosedness (s4) and affection (s7) (p = 0.002; F values were in highest absolute values respectively as 9,624, 9,439, and 10,054) were better determined by the 3D urban model than by the 2D mapping technique. The variable of h1 which referred to cognition of change in the historic townscape (mean value = 5.75 in the first group and mean value = 6.17 in the second group) were also defined better in the 3D urban model than in the 2D mapping technique (F = 7,625; p = 0.006).
Two groups' means and standard deviations for SMB factors were also presented with their significance levels in Table 3. The highest difference between the responses for 2D and 3D visualization techniques was for sense of affection (s7). The mean values of all components were higher for the second group, to whom the 3D urban model was presented. In accordance with the responses for the unity factor (s3) and enclosedness factor (s4), the 3D model was definitely a better tool to represent how well all the various parts of the historic townscape fit together into a coherent and functional whole with high level of sense in spatial enclosure and demarcation than the 2D mapping technique. The sense of affection factor was also responded to in favor of 3D urban model in that the quality of recognition, giving rise to a sense of familiarity, was successfully comprehended regarding the age of the environment. Responses

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?	t1	Structural condition
2. analysis of visual quality define the site?	t2	Visual quality
3. analysis of accessibility and privacy define the site?	t3	Accessibility and privacy
4. analysis of architectural harmony define the site?	t4	Architectural harmony
Part II. Cognition level of historic townscapeTo what extent do you perceive…		
5. change in historic townscape?	h1	Historical evolution
6. listed buildings in the site?	h2	Listed buildings
Part III. Perception level of SMB scale factorsTo what extent do you perceive…		
7. an environmental quality of being pleasant and secure?	s1	Pleasantness
8. a degree of variation or intensity, contrast and abundance?	s2	Complexity
9. a coherent whole in which various parts of environment fit together?	s3	Unity
10. a sense of spatial enclosure and demarcation?	s4	Enclosedness
11. an expression of power in the environment and its various parts?	s5	Potency
12. an expression of social status representing the built environment?	s6	Social status
13. a sense of affection regarding quality in historic environment?	s7	Affection
14. a sense of originality with surprising elements in the environment?	s8	Originality

Table 2. Definition of variables.

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for potency factor (s5) and social status (s6) reported that sense of power in townscape and evaluation of the built environment in socio-economic terms were efficiently expressed in terms of maintenance, as depicted by the 3D urban model.
As less-significance levels occurred between the two groups, it was reported that significance values were on the level more than 0,05 which were not statistically significant. However, the least distinctive results were those of pleasantness (s1) and complexity (s2) which had the lowest mean difference (the significance levels were respectively as p = 0,124 and p = 0,099) when compared to other SMB factors. The pleasantness factor determined the representation of environmental quality of being pleasant, beautiful and secure and complexity factor determined the degree of variation or intensity, contrast and abundance in the built environment. These two factors were directly related to aging and deterioration in the historic townscape. The reason for the insignificant responses for pleasantness (s1) and complexity (s2) factors was that the 3D urban model did not represent the urban historic site in realistic detail by neglecting corrosions and the deterioration of the urban façades for the purpose of abstraction. The 3D urban model in this study was reported as less capable of representing real urban environment in these SMB factors (only s1 and s2) because of not having material or texture characteristics on façades with a realistic rendering function.

CONCLUSION

In conclusion, the 2D mapping technique was less capable of creating sense of affection in representation of change in the historic townscape than the 3D urban model. On the contrary, the 3D urban model was more capable of representing townscape characteristics, including structural condition, visual quality and traditional listed buildings than the 2D mapping technique. The most distinctive findings were also reported by comparing the results from professional and non-professional groups (Koramaz and Gülersoy-Zeren, 2009a). In accordance with the responses from plan-

Codes	Variable Names	1. Group, 2D n: 115		2. Group, 3D n: 115		F	p.
		mean	s.d.	mean	s.d.		
Part III. Perception level of SMB scale factors							
t1	Structural condition	5.16	1.19	**5.59**	1.02	8,883	**0,003**
t2	Visual quality	5.28	1.59	5.59	1.08	3,052	0,082
t3	Accessibility and privacy	5.10	1.70	5.43	1.13	3,180	0,076
t4	Architectural harmony	5.52	1.33	**5.93**	1.03	6,798	**0,010**
Part II. Cognition level of historic townscape							
h1	Change in historic townscape	5.75	1.35	**6.17**	0.90	7,625	**0,006**
h2	Listed buildings	5.67	1.44	**6.02**	1.09	4,270	**0,040**
Part III. Perception level of SMB scale factors							
s1	Pleasantness	4,09	1,47	4,37	1,35	2,378	0,124
s2	Complexity	5,05	1,37	5,33	1,17	2,750	0,099
s3	Unity	4,35	1,52	**4,90**	1,13	9,624	**0,002**
s4	Enclosedness	4,57	1,40	**5,10**	1,16	9,439	**0,002**
s5	Potency	5,27	1,27	**5,60**	1,23	3,996	**0,047**
s6	Social status	4,17	1,43	**4,59**	1,41	4,940	**0,027**
s7	Affection	5,19	1,37	**5,72**	1,16	10,054	**0,002**
s8	Originality	5,07	1,36	**5,47**	1,23	5,490	**0,020**

Table 3. Comparison of 2D and 3D visualization techniques. 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=statistics, p=significance values).

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ning and conservation professions, the most important features of the 3D urban models' were:
- Explanation ability of conservation project and interventions to structural and visual quality of urban historic environments,
- Representation ability of change in the historic townscape of urban environments,
- Improvement of the cognition and perception levels of urban historic environments with the creation of spatial unity, enclosedness and affection sense.

As the non-professional group, high school students responded especially to one of the three features of the 3D urban model above. In accordance with high school students' sense of affection to urban historic environment, the 3D urban model was efficient in representing the urban pattern whether it maintained architectural vernacular characteristics or not.

As reported in the study, the significant differences, termed as structural condition, architectural harmony and listed traditional buildings, were also those concerning the representation capability of change in the historic townscape by 3D visualization techniques. The study also indicated that another distinctive parameter was the cognition level of townscape characteristics of the urban historic site which is explicitly explained as the purpose of the study.

As semantic environmental scale (SMB) factors were significantly discriminated in two visualization techniques, these factors were efficiently stated as a validated measurement scale for comparing users' responses for 2D and 3D visualization techniques (Koramaz, T.K. and Gülersoy-Zeren, N., 2009b). The results indicated also the fact that user groups commonly gave higher scores to the 3D urban model when comparing the scores to the 2D mapping technique. Overall, the results showed that the methodology was valuable when comparing the efficiency of visualization techniques in representing urban historic sites.

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