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Comparison of design alternatives generated by computer aided design and user expectations from small urban spaces

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This study investigates the compliance of alternative design models based on perception of designer and users by creating 3D models of the fields before construction. The application part of this work presents 4 different ground cover materials, modeled on the computer, that were proposed for 2 predetermined small urban areas to apply the design in the highest demand. Questionnaire participants were then asked to rate 10 different pairs of adjectives selected for these areas and design proposals. As a result different material suggestions helps designer and users to chose the best option within various alternative designs. Also by applying SDS analyses the study shows the visual perception of users for the materials to be applied in terms of adjectives.

Key words: Urban area, open space, computer aided design (CAD), modeling, visualization.

INTRODUCTION

Visualization technology is a part of a larger computer revolution that has transformed the design professions of architecture, as well as planning (Levy, 2011). Landscape visualisation can bring large data sets to life and enable people to become part of an interactive decision-making process (Stock et al., 2008). Many studies have used landscape visualisation and environmental planning (Auclair et al., 2001; Bishop et al., 2001; Danahy, 2001; Lange, 2001; Egger et al., 2001; Appleton and Lowett, 2003; Pettit et al., 2006; Stock et al., 2007; Pettit el al., 2009). Furthermore, visualizations are now directly linked to data, which improves the capacity for creating urban design scenarios embedded with data such as floor area ratios, proportions of different uses and site coverage (Senbel et al., 2013). While professional planners can rely on experience to visualize proposed landscapes, laypersons are usually overwhelmed by abstract, graphically sparse mapping and other forms of representation and cannot translate this information into landscape images. Landscape planning would therefore benefit from technological improvements in 3D visualization tools (Paar, 2006). Modeling of environmental landscape design provides various advantages, including enabling the designer to visually describe the design to other parties (Honjo and Lim, 2001; Lim and Honjo, 2003; Carver and White, 2003; Lewis and Sheppard, 2006; Paar, 2006; Wang et al., 2008; Yim et al., 2009).

Textures on landsurface

3D objects are the fundamental building blocks used to create landscape scenes and virtual worlds (Pettit et al., 2009). Before the data of 3D program models can be exported into a 3D author environment, it is usually

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Figure 1. Study areas.

Table 1. Levels of the research (Hsu et al., 2000).

	Level I		Level II Semantic differential scale(SDS)
	a. Assessing the study areas	***b. Select adjectives and 3D modeling***	
Purpose	To identify the design areas	To choose surface texture maps and adjectives	To determine user preference for two different areas
Subject	Designers: 2	Designers: 10	User: 45
Material	2 different open space areas	4 alternative models for 2 different areas	Questionneries of 4 alternatives for each of two areas
Task	Literature review	Use computer and 3D modeling programs	SDS test, SPSS - Paired T Test

necessary to do some preparation regarding the geometric information and the textures (Mach, 2006). For the visualization, a texture map will generally represent the color of the ground. The terminology originates from computer graphics and does not actually mean 'texture', but rather color (Bishop and Lange, 2005).

Texture mapping consists of the following steps:

1. Create a texture object and specify a texture for that object.
2. Indicate how the texture is to be applied to each pixel.
3. Enable texture mapping.
4. Draw the scene, supplying both texture and geometric coordinates.

This study examines the use of computer supported design and virtual reality (VR) technologies in urban and landscape design, as well as the changes at the various stages from design to modeling and presentation. 3D modeling is mostly used for changing terrain analysis of areas. This study application is of small scale area and is about landscape elements that are used in urban design projects. An analysis of the impact of users' preferences on landscape designs has been carried out.

MATERIALS AND METHODS

The first stage of the modeling process required the assembly of a landscape feature database. The area surrounding Karadeniz Technical University (KTU), a university established in 1955 in the City of Trabzon of Turkey, was chosen for this purpose (Figure 1).

Field applications of this study included the area outside the Rector's Building and the area in front of the Atatürk Statue on the main Kanuni Campus. This research is divided into two levels: Level I (Preparing design alternatives) and Level II (Semantic differential scale), as summarized in Table 1.

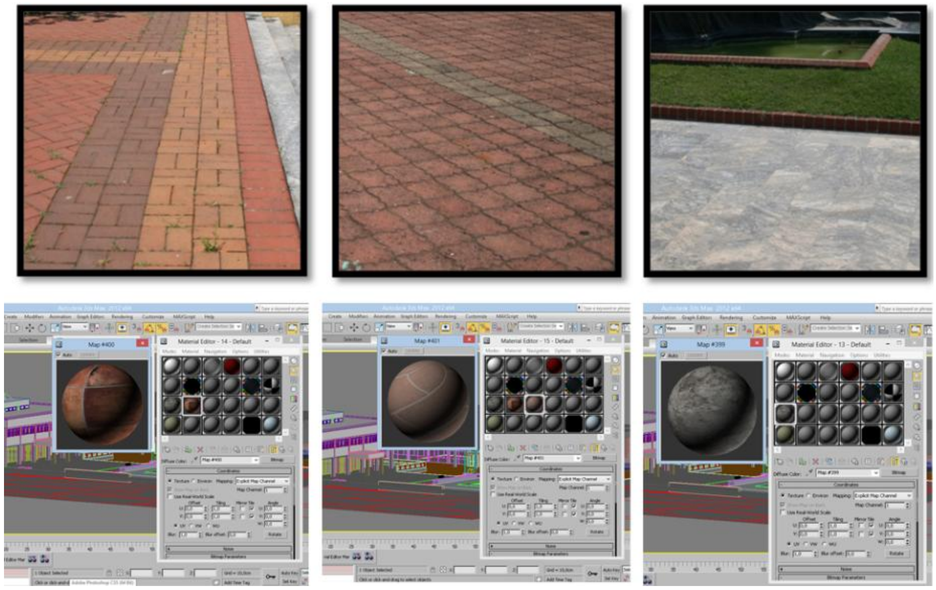

Figure 2. Real textures and texture mapping.

Level I -a. Assessing the study areas

Subject: The numerical data for the study area and projects were obtained from Karadeniz Technical University's Department of Geodesy and Photogrammetry in electronic format as 2D drawings. Two designers were selected from the academic staff of the Landscape Architecture Department. They were 40 to 50 years old and with an educational background in landscape design.

Materials: Alternative open space areas, chosen from KTU Kanuni Campus.

Procedure: Open space areas of academic staff selection, according to variety of events have been evaluated.

Results: At this stage, the academic staffs were allocated to 2 different open space areas for the research at 5 alternative areas. Both design areas are of special significance to the university and are commonly used for celebrations and special events.

Level I - b. Select adjectives and 3D modeling

Subject: This stage included 10 academic staff including 5 from the department of landscape architecture, 3 from the department of architecture and 2 from the department of urban and regional planning.

Materials: Floor textures in study areas (Figure 2). CAD and VR technologies as well as the changes that occur in each stage from design to modeling and presentation are used in landscape design.

Procedure: Academic staffs were provided some suggested textures that were photographed in real environments and modeled areas in 3D Studio Max.

Results: 4 alternative models were rendered to each of the chosen areas; visuals were created using 3D Studio Max. The software mostly used for 3D reconstruction is 3D Studio Max, because of the excellent management capabilities of polimesh, essential to get photorealistic mapping of the digital model (Turco and Sanna, 2009). At the end of the academic study, 10 different adjective pairs were chosen (Table 2).

Level II - Semantic differential scale (SDS)

Subject: The participants were selected from the academic staff, administrative staff and students of Karadeniz Technical University and divided into three groups. 15 individuals from each of the 3 groups were selected to complete the questionnaires. Care was taken during the selection process to randomly choose individuals from different departments. The academic staff and student groups were randomly selected from the departments of landscape architecture, architecture, civil engineering, mining engineering, English language and literature, forestry engineering and physics. The administrative employees that were selected came from the Student Affairs Directorate and the President's Office due to their location near the study areas. The positional characteristics of the study areas were a consideration of the participant selection process. The chosen areas of the Karadeniz Technical University's Kanuni Campus also limited the participant profile.

Materials: The participants were given a list of 10 adjective pairs to choose from in relation to each photograph showing a different design proposal. For each photograph, they were asked to choose one of the adjectives in the pair for each photograph.

Procedure: SDS is a rating scale designed to measure the connotative meaning of objects, events, and concepts or attitudes.
It is developed by Osgood et al. (1967) to measure connotative meaning was selected to obtain judgments of meaning from the various respondent groups on the architectural material, this scale can be used to evaluate attention and perception. Human perception is important and meaning value is important perception for choose human behavior (Creelman, 1966; Osgood et al., 1967) and unquestionably involved with human feelings (Hershberger,

Table 2. The 15 adjective pairs used in the pilot test - The 10 adjective pairs used in the study.

Interesting	**Not interesting**
Congruent with the environment	Not congruent with the environment
Striking	Not striking
Modern	**Traditional**
New	**Old**
Looks artificial	Does not look artificial
Looks natural	Does not look natural
Creative	**Unoriginal**
Systematic	Irregular
Lively	Not lively
Orderly	Disorderly
High-tech	**Handmade**
Directing	Not directing
Luxurious	**Plain**
Can be perceived	Cannot be perceived

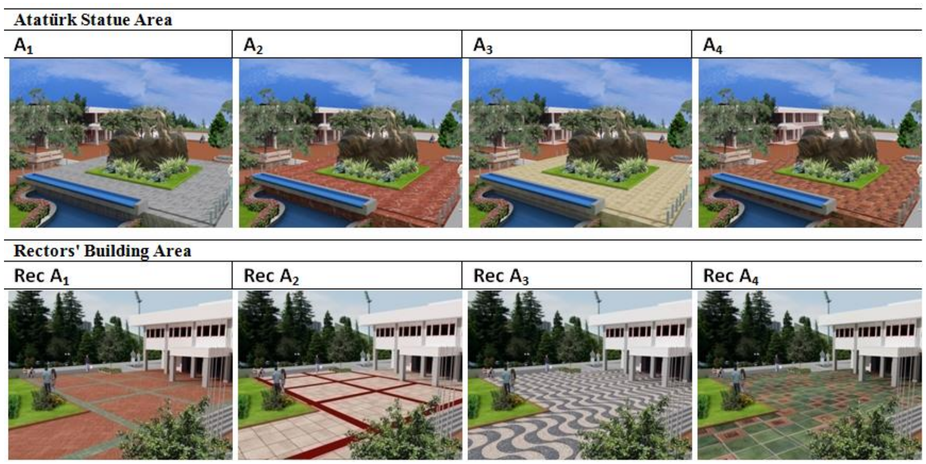

Figure 3. Alternative floor textures for both study areas.

1969).

Participants evaluated virtual photographs one by one and completed questionnaires. An average of 2 min was given for each picture, and it took participants an average of 16 min to complete a questionnaire. The statistical studies of both proposed for the area which is the most preferred photo Paired Samples Test was performed to reveal. This analysis of statistical data analysis package SPSS 17.0 software was used to determine. Preferred photographs of the study area were determined according to the adjective pairs. The aim of the test was to question the difference in color, form and style of floor covering of the two environmental areas and the three propositions made for them. The visual materials made by modeling, which may be used for the selection of floor covering, have been shown in previous studies (Feibush and Greenberg, 1980; Schnabel and Petutschnigg, 2011).

Results: Paired comparisons were used to find which adjective pairs were better liked for the given area, as suggested by questionnaires.

RESULTS

This study focuses on the use of computerized drawing and design techniques, which are becoming increasingly common in landscape design. Landscape elements of the selected areas were evaluated according to human preferences. The questionnaire aimed to list various proposed design compositions in order of preference. With the use of the SDS in the questionnaires, the study showed how humans can have different perspectives on a given area.

The distribution of adjective pairs for each photograph was considered during the evaluation of the study's adjective pair data. The preferred photographs (A4, RecA4) were those congruent with the environment and more natural in appearance (Figure 3). The different colors,

Table 3. Mean values of adjectives in both areas.

Adj		**Atatürk Statue Area**				**Rectors' Building Area**			
		A_1	**A_2**	**A_3**	**A_4**	**Rec A_1**	**Rec A_2**	**Rec A_3**	**Rec A_4**
Interesting	**Mean values**	3.33	5.07	4.51	**5.09**	3.71	5	5.89	**5.92**
Congruent with the environment		4.18	5.11	3.87	**5.8**	5.44	4.13	2.56	**6**
Striking		3.93	5.2	4.38	**5.24**	3.98	5.18	**5.89**	5.76
Looks artificial		**5**	4.42	4.91	4.24	4.53	5.2	**5.67**	2.98
Looks natural		3.47	4.31	3.64	**4.49**	3.8	2.82	2.47	**5.51**
Systematic		**5.27**	4.11	5.2	5.2	**5.91**	5.73	4.49	4.6
Lively		3.73	5.13	4.33	**5.27**	4.33	5.09	5.07	**5.2**
Orderly		**5.58**	4.36	5.44	5.24	**5.98**	5.84	4.33	4.96
Directing		3.89	3.84	**4.53**	4.29	**4.58**	5.24	4.29	4.16
Can be perceived		5.16	5.04	**5.56**	5.4	5.47	**5.67**	5.13	5.04

forms, textures and styles of paving stones revealed the participants' different preferences regarding adjective pairs. As a result of the SPSS 17.0 paired sample T-test conducted on the 10 adjective pairs selected for the 2 different areas, no significant difference was observed between the 3 groups of participants and the overall study group (Table 3).

The effects of adjective pairs selected when using the SDS technique on each other were studied. When the entire data were considered, image A4 of the area around the Atatürk Statue and Rec A4 of the area outside the Rector's Building ($0.5 < p < 0.01$) had the highest value for being interesting for all alternative photographs in both areas as a result of adjective pair scoring. This image was followed by image A4 for being interesting (mean:5.09), congruency with the environment (mean:5.8),striking (5.24), looking natural (mean:4.49) and lively (mean:5.27). However, RecA4 was interesting (mean:5.92), congruent with the environment (mean:6.00), and looked natural (mean:5.51) and lively (mean:5.2).

Correlation analysis demonstrated the adjective pairs for both areas (Tables 4 and 5). Both in the study areas, in terms of adjectives number 4 is preferred. For the area in front of the Atatürk statue, is interesting in terms of the value because of the textures used adjective pairs also affected congruent with the environment (383**), striking (687**), looks natural (533**), lively (545***). Users would like to see the area as natural. As a result of the correlation study, the artificial adjective pairs was not affected by the value of other adjectives. The result of the work to the Rector area, has been affected by more than one another adjective pairs (congruent with the environment, striking, lively). Within this field, an artificial adjective value is not affect the other adjective values.

A4 and Rec.A.4 are pictures selected from both suggested areas and were selected primarily by the administrative staff. Results suggest that alternative areas were found to be administrative staff buildings. Table 6 show the alternative photos chosen in terms of adjective pairs to groups of occupation.

DISCUSSION

This study aims to develop realistic solutions for urban design projects by offering alternatives that proceed the design process with the help of computerized visualization programs. It is well known that computerized visuals of alternative products have been developed in many architectural and design fields. Many studies (Maurer et al., 1992; Debevec et al., 1996; Ervin and Hasbrouck, 1999; Ervin and Hasbrouck, 2001; Dick et al., 2004; Sinha et al., 2008; Jiang et al., 2009) have been proposed for this purpose.

There are few forms in architecture to which human do not attach some meaning either by way of convention, use purpose or value. Paar (2006) explains that, at present, landscape visualization seems to have been widely adopted for assessing controversial or large scale projects, simulating landscape changes, and research purposes. In the past studies, most geospatial features, including terrain, roads, water bodies, vegetation and residence blocks, have been successfully modeled via various two-dimension (2D) data structures and tools (Stambouloglou and Shan, 2002). When comparing 2D and 3D images, the former seems to have the architectural advantage of being drawn on a computer; however, 3D drawings affect human perception more profoundly. Therefore, architects prefer to see the spaces they design in 3D models. 3D modeling may also be preferred for urban planning prior to the real implementation.

The location of these environmental areas in a public space affected the adjective pairs. If users wish to see a natural and lively area, they prefer dynamic, colorful, non-systematic ground covering. In conclusion, the proportional increase or decrease in adjective pairs reveals whether a space is preferred as looking static or dynamic, colorful or lively, systematic or chaotic. When determining visual preferences, participants were asked to evaluate different alternatives modeled in the virtual environment using a real photograph of the area. The location of these environmental areas in a public space

Table 4. Correlation analysis for the area around Atatürk Statue.

Parameter		Interesting	Environment	Striking	Artificial	Natural	Systematic	Lively	Orderly	Directing	Perceived
Interesting	Pearson Correlation	1	0.383**	0.687**	-0.335*	0.533**	-0.039	0.545**	-0.010	0.116	0.205
	Sig.(2-tailed)		0.010	0.000	0.024	0.000	0.799	0.000	0.950	0.448	0.177
	N	45	45	45	45	45	45	45	45	45	45
Environment	Pearson Correlation	0.383**	1	0.157	-0.281	0.279	0.261	0.457**	0.346*	0.052	0.113
	Sig.(2-tailed)	0.010		0.302	0.062	0.064	0.084	0.002	0.020	0.735	0.459
	N	45	45	45	45	45	45	45	45	45	45
Striking	Pearson Correlation	0.687**	0.157	1	-0.234	0.426**	0.150	0.435**	0.117	0.208	0.238
	Sig. (2-tailed)	0.000	0.302		0.121	0.003	0.324	0.003	0.444	0.171	0.115
	N	45	45	45	45	45	45	45	45	45	45
Artificial	Pearson Correlation	-0.335*	-0.281	-0.234	1	-0.711**	0.271	-0.396**	0.247	0.244	0.110
	Sig.(2-tailed)	0.024	0.062	0.121		0.000	0.071	0.007	0.101	0.107	0.472
	N	45	45	45	45	45	45	45	45	45	45
Natural	Pearson Correlation	0.533**	0.279	0.426**	-0.711**	1	-0.054	0.509**	-0.064	-0.047	0.033
	Sig.(2-tailed)	0.000	0.064	0.003	0.000		0.727	0.000	0.674	0.757	0.831
	N	45	45	45	45	45	45	45	45	45	45
Systematic	Pearson Correlation	-0.039	0.261	0.150	0.271	-0.054	1	-0.043	0.789**	0.258	0.086
	Sig.(2-tailed)	0.799	0.084	0.324	0.071	0.727		0.778	0.000	0.087	0.575
	N	45	45	45	45	45	45	45	45	45	45
Lively	Pearson Correlation	0.545**	0.457**	0.435**	-0.396**	0.509**	-0.043	1	-0.082	0.288	0.414**
	Sig.(2-tailed)	0.000	0.002	0.003	0.007	0.000	0.778		0.592	0.055	0.005
	N	45	45	45	45	45	45	45	45	45	45
Orderly	Pearson Correlation	-0.010	0.346*	0.117	0.247	-0.064	0.789**	-0.082	1	0.328*	0.254
	Sig.(2-tailed)	0.950	0.020	0.444	0.101	0.674	0.000	0.592		0.028	0.092
	N	45	45	45	45	45	45	45	45	45	45
Directing	Pearson Correlation	0.116	0.052	0.208	0.244	-0.047	0.258	0.288	0.328*	1	0.493**
	Sig.(2-tailed)	0.448	0.735	0.171	0.107	0.757	0.087	0.055	0.028		0.001
	N	45	45	45	45	45	45	45	45	45	45
Perceived	Pearson Correlation	0.205	0.113	0.238	0.110	0.033	0.086	0.414**	0.254	0.493**	1
	Sig.(2- tailed)	0.177	0.459	0.115	0.472	0.831	0.575	0.005	0.092	0.001	
	N	45	45	45	45	45	45	45	45	45	45

*,** Correlation is significant at the 0.05 and 0.01 levels (2-tailed), respectively.

Table 5. Correlation analysis for the area outside the Rector's Office.

Parameter		Interesting	Environment	Striking	Artificial	Natural	Systematic	Lively	Orderly	Directing	Perceived
Interesting	Pearson Correlation	1	0.478**	0.547**	-0.271	0.208	-0.044	0.513**	0.006	0.243	0.327*
	Sig. (2-tailed)		0.001	0.000	0.071	0.171	0.774	0.000	0.966	0.108	0.028
	N	45	45	45	45	45	45	45	45	45	45
Environment	Pearson Correlation	0.478**	1	0.688**	-0.298*	0.545**	0.000	0.556**	0.062	0.162	0.574**
	Sig. (2-tailed)	0.001		0.000	0.047	0.000	10.000	0.000	0.688	0.286	0.000
	N	45	45	45	45	45	45	45	45	45	45
Striking	Pearson Correlation	0.547**	0.688**	1	-0.476**	0.546**	0.229	0.571**	0.154	0.375*	0.452**
	Sig. (2-tailed)	0.000	0.000		0.001	0.000	0.130	0.000	0.312	0.011	0.002
	N	45	45	45	45	45	45	45	45	45	45
Artificial	Pearson Correlation	-0.271	-0.298*	-0.476**	1	-0.681**	0.078	-0.240	0.213	-0.069	-0.172
	Sig. (2-tailed)	0.071	0.047	0.001		0.000	0.610	0.112	0.160	0.654	0.260
	N	45	45	45	45	45	45	45	45	45	45
Natural	Pearson Correlation	0.208	0.545**	0.546**	-0.681**	1	0.031	0.488**	0.018	0.086	0.375*
	Sig. (2-tailed)	0.171	0.000	0.000	0.000		0.841	0.001	0.907	0.573	0.011
	N	45	45	45	45	45	45	45	45	45	45

Table 5. Contd.

Systematic	Pearson Correlation	-0.044	0.000	0.229	0.078	0.031	1	0.307*	**0.874****	**0.772****	0.267
	Sig. (2-tailed)	0.774	10.000	0.130	0.610	0.841		0.040	0.000	0.000	0.076
	N	45	45	45	45	45	45	45	45	45	45
Lively	Pearson Correlation	**0.513****	**0.556****	**0.571****	-0.240	**0.488****	0.307*	1	**0.385****	0.358*	**0.582****
	Sig. (2-tailed)	0.000	0.000	0.000	0.112	0.001	0.040		0.009	0.016	0.000
	N	45	45	45	45	45	45	45	45	45	45
Orderly	Pearson Correlation	0.006	0.062	0.154	0.213	0.018	**0.874****	0.385**	1	**0.709****	0.287
	Sig. (2-tailed)	0.966	0.688	0.312	0.160	0.907	0.000	0.009		0.000	0.056
	N	45	45	45	45	45	45	45	45	45	45
Directing	Pearson Correlation	0.243	0.162	0.375*	-0.069	0.086	**0.772****	0.358*	**0.709****	1	0.335*
	Sig. (2-tailed)	0.108	0.286	0.011	0.654	0.573	0.000	0.016	0.000		0.025
	N	45	45	45	45	45	45	45	45	45	45
Perceived	Pearson Correlation	**0.327***	**0.574****	**0.452****	-0.172	0.375*	0.267	**0.582****	0.287	0.335*	1
	Sig. (2-tailed)	0.028	0.000	0.002	0.260	0.011	0.076	0.000	0.056	0.025	
	N	45	45	45	45	45	45	45	45	45	45

*,** Correlation is significant at the 0.05 and 0.01 levels (2-tailed), respectively.

Table 6. General distrubution by occupation of both areas

Adj	A_4			Rec A_4		
	Academic	**Student**	**Administrative**	**Academic**	**Student**	**Administrative**
Interesting	5	**9**	10	9	**10**	**14**
Congruency with the environment	**13**	**9**	**12**	**12**	9	13
Looking natural	3	6	9	9	9	12
Lively	5	8	9	6	6	11

affected the adjective pairs to SDS.

Conclusion

İn a field survey analysis for an area to be designed, surveyors who are actual users of the area can make much more realistic suggestions.

Due of their advantages concerning design time, alternative production, realistic presentation and speed, computerized modeling methods have become more widespread not only in urban design, but in all subfields of architecture.

A second outcome of the study was the exploration of the interrelationships between the adjective pairs. They were studied by considering the purposes of the space. Materials and fittings were selected according to the functions and users of a space; creating alternatives in line with users' wishes results in more realistic designs that reflect these wishes.

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