Development of an Educational Video Game for the Teaching of Landscape Grading Principles

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Abstract: Landscape grading is a highly critical topic in the landscape architecture curriculum, which provides crucial skills for students, such as three dimensional visual imagination, critical thinking, management and problem solving. This research aims to develop an educational video game as a learning support tool that helps undergraduate landscape architecture students to acquire the essential knowledge and skills for the basics of landscape grading. In addition, this research focuses on supporting the conventional education system by assisting students to gain essential knowledge and skills through achieving the given well-designed learning tasks. In order to enhance motivation and increase learning rate, this educational video game helps students to practice: (1) understanding of the contour map and its rules, (2) identifying the signature landforms and slope shapes, and (3) preparing landscape grading projects to solve storm water drainage problems.

This research aims to facilitate the learning of landscape grading topics by visualizing the textual curriculum with three-dimensional models, instructional images and animations. This research also aims to engage students in the learning of landscape grading topics by employing the game mechanics by blending the conventional teaching tools with the opportunities of the gaming technologies. Moreover, the proposed video game presents an immersive self-oriented learning environment that allows students to learn actively by accessing information in a hyperlinked network rather than being listeners of streaming information. The importance of this research lies in the use of existing digital technologies to enhance the learning rate for landscape architecture education as a response of literature deficiency in landscape architecture.

In this research, three problem-based learning scenarios were created based on the curriculum and divided into instructional and training tasks. The instructional tasks refer to the tutorial tasks, which focus on increasing the understanding and learning of content and encouraging students to engage themselves in the learning process by explaining through the clearly and well-defined instructions. The training tasks allow students to exercise in curricular topics by achieving the given tasks. In addition, the difficulty level of training tasks steps up gradually and mentoring support is reduced to help students to increase expertise on given topics. Afterwards, a three-dimensional educational video game was created based on the learning scenarios by re-programming the OpenSimulator software using the LSL scripting language.

A three-phased experimental study was conducted in order to overcome the deficiencies identified through evaluations of the prior study; the authors have improved the software. The new improved version was tested on two randomly selected groups (n=32) (control and experiment) of undergraduate landscape architecture students at Istanbul Technical University in order to evaluate the pedagogical and instructional effects of the proposed video game. As a result of the gathered qualitative and quantitative data, two-tailed paired samples *t*-test revealed that the experimental group scored 15.42 % higher points ($m = 47.1800$, $s = 9.17499$) compared to the control group ($m = 31.7667$, $s = 4.62667$), $t(2) = 2.030$, $p \leq .05$.

Keywords: Landscape architecture education, landscape grading, virtual learning environments

Journal of Digital Landscape Architecture, 1-2016, pp. 308-315. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-612-3, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537612035.

1 Introduction and Prior Research

MARC PRENSKY (2001) supports the idea of radical change in the brains and learning ways of the generation that has spent their time mostly in interacting with computers, smartphones and tablets, and defines them as *digital natives*. According to his statement, digital natives are inclined to learn faster by reading visual information rather than textual, connecting information in a hyperlinked network in order to their decisions and being granted during the learning process. Moreover, Prensky points out the clash between this generation and the recent education practice and suggests utilizing computer games and digital game technologies in education as a familiar interface for them. Although conventional wisdom argues that playing computer games is a harmful and inefficacious activity, recent scientific studies reveal the benefits of utilization of such software as educational tools. GREEN & BAVELIER (2003, 2007) conducted an experimental study to explore the beneficial uses of video games by measuring the cognitive, visional and comprehensive abilities of game players and non-gamer individuals. This study reveals that game players are more capable compared to non-gamers. Moreover, the action genre video games can be used to improve these abilities of players who were trained by playing this genre of video game.

In the computer-based training and e-learning industry, a three-dimensional virtual environment takes an important role due to its connection, customization and collaboration abilities, and low hardware demand (it can be used even in smartphones). Virtual environments allow users to connect and create models, share information via using built-in tools in virtual medium. Virtual worlds were used to engage students for science learning by situating students in simulated settings where they would be necessitated to develop problem-solving and critical thinking skills (DADE et al. 2004, BARAB et al. 2004). In addition, this software was used by design educators (GÜL et al. 2012) as a design medium for graduate architecture students, taking architecture students of Istanbul Technical University and University of Sydney as two geographically dispersed universities. In this project, *Global Teamwork,* researchers explored the potentials of such a medium for communication modes in the architectural design process on collaborative learning activity by employing the software as a communication and design platform between the students. Students used the immersive virtual environment platform as a communication and design tool for brainstorming the design principles and modeling the designs in the virtual environment through the embedded modeling tools. These studies explore the educational potential of such virtual reality technologies by presenting learning material in an immersive and interactive way, to allow students to acquire knowledge and experience by exploring, solving problems in a simulated environment.

This research focuses on developing an educational video game for assisting undergraduate landscape architecture students in order to teach the landscape grading topic. Moreover, this research presents the empirical findings of an experimental study for evaluating the instructional and motivational effects of the educational video game.

This research consisted of a series of experimental studies. The first experimental study was conducted (n=16) on a group of undergraduate-level landscape architecture students in Florida International University, in 2013-14 spring semester. The first study focused on facilitating and engaging the learning of signature landforms. Afterwards, the second experimental study was conducted (n=16) in 2014-15 fall semester as a part of Landscape Construction I course on 3rd semester undergraduate students at FIU (ÖRNEK & ÖZER 2014). This study was focused on assisting students in learning landscape grading principles and procedures for preparing a site for a housing project. In this research, the third experimental study was conducted (n=32) in 2015-16 fall semester as a part of Landscape Construction I course on 3rd semester undergraduate students at Istanbul Technical University. This final study was focused on blending analogue and digital technologies in a virtual learning environment to assist students in learning of whole landscape grading curriculum, which is formed by a three-phased learning scenario.

2 Research

This research presents an educational video game, which supports and guide students in order to solve complex landscape grading problems to acquire the essential knowledge via the problem-based tasks. These tasks help students to comprehend the learning material by defining the problem and its substance clearly. They also provide the crucial information and feedback as required. In addition, this educational video game gradually decreases the need for guidance and tries to develop students' problem-solving skills, like raising the support wheels of a bicycle higher as the child's sense of balance skill increases.

2.1 Methodology

The proposed video game was developed by employing OpenSimulator (2016) software, which is an open-source virtual environment software and is based on the core of SecondLife, the most popular immersive virtual environment (2016). The OpenSimulator software allows users to create three-dimensional immersive virtual environments and to share with other users through using client software like Singularity Viewer (2016) via *Internet* and *Local Area Networks*. In order to develop the educational video game, a virtual environment server was set up and re-programmed using the LSL scripting language.

The educational video game was improved and optimized following the feedbacks gathered from previous studies. According to this feedback:

- A series of learning tasks was designed in order to improve relationship with the complete curriculum.
- Mentoring system was updated to reduce guidance increasingly during tasks.

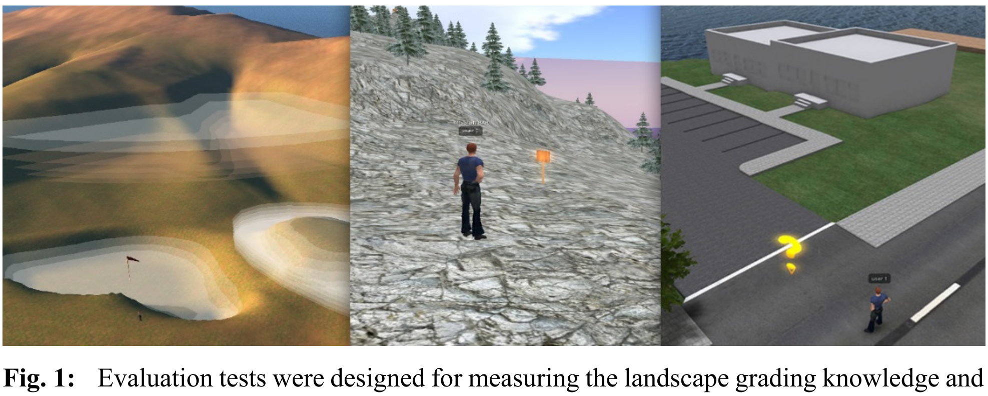

Fig. 1: Evaluation tests were designed for measuring the landscape grading knowledge and skills of students for different scales

- An interactive topography modifying tool was enabled to allow students to solve grading problems.
- Minor technical problems were fixed.
- Two more game levels were created according to the learning scenario in order to improve relationship with the complete curriculum.

2.2 Data Gathering Tools

The qualitative and quantitative data were gathered through the pre-tests, post-tests and a questionnaire. The tests were focused on evaluating the knowledge, comprehension and drawing capabilities of students and mostly required drawing. The tests were also designed to guide students in the virtual learning environment. Specifically, the first phase tests are focusing on evaluating knowledge and technical skills on designing topography and developing contour maps. The related tasks require how to read elevation, contours, and landforms and how to create topography sections. The second phase tests were focused on understanding slopes and basic grading principles. The related tasks require how to grade a site to build a sports field on it. The third phase tests were focused on understanding landscape grading principles for designing a sustainable storm water drainage system. The related tasks require how to grade a project site with two adjacent buildings and a parking lot (Figure 2).

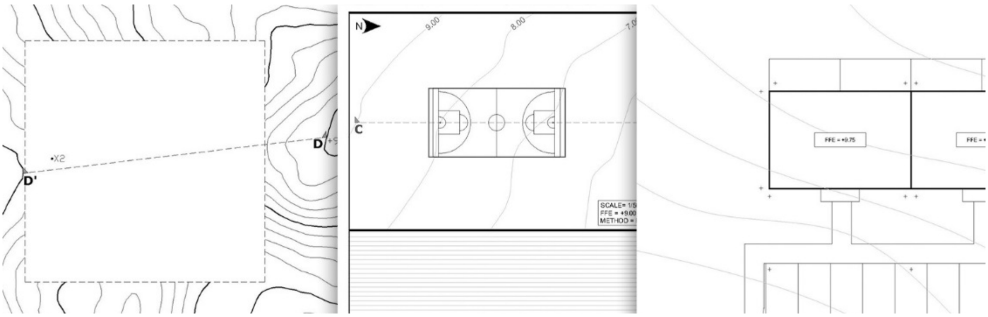

Fig. 2: Evaluation tests were designed for measuring the landscape grading knowledge and skills of students for different scales

In addition to learning outcomes, user experience plays an important role in the experimental study. For that purpose, an online questionnaire was designed using Google Forms (2016) to evaluate the motivational effects of the virtual learning environment on learning of participants (Figure 3). The questionnaire contains 33 items with a 7-point Likert response scale and 4 it ems for qualitative responses.

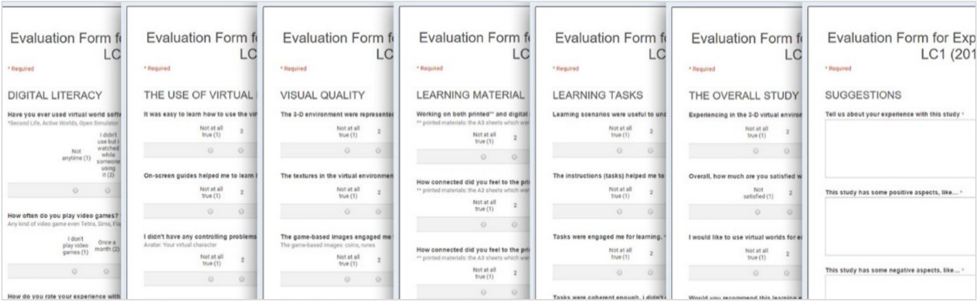

Fig. 3: Questionnaire for measuring the user experience of participants in the virtual learning environment

2.3 Experimental Study

The experimental study was formed in three steps: (1) application of pre-tests for both groups, (2) playing the educational video game for the experimental group and an instruction course for the control group, (3) application of post-tests for both groups. Pre-tests were applied to both groups to measure the prior knowledge level about the topic of participants, at the beginning of the classes. Afterwards, the experimental group was required to follow the instructions and achieve the given tasks in the virtual learning environment, while the control group was being instructed through conventional learning methods. Afterwards, post-tests were applied at the end of classes, to measure the acquired knowledge and skills compared to pre-tests (Figure 4).

Fig. 4: Photos of the participants during the experimental study

3 Findings

The qualitative and quantitative data were gathered from the pre-test and post-test, which were evaluated on a 100 rating scale. Afterwards, the pre-test and post-test results were compared between the experimental and control groups. For that purpose, an independent samples test was conducted in order to validate the homogeneity and equality of experimental and control groups. The test results revealed that the experimental and control groups can be treated as equal ($p_{1, 2, 3} > 0.05$) for each phase of the experimental study. The results also states that there is no difference in the variances between the groups.

Table 1: Independent samples t-test reveals that the experimental and control groups are equal and homogenous according to their pre-test results for each phase

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95 % Confidence Interval of the Difference	
									Lower	Upper
Phase 1	Equal variances assumed	**,649**	,429	,530	22	,601	4,60417	8,68288	-13,40303	22,61137
	Equal variances not assumed			,530	21,349	**,601**	4,60417	8,68288	-13,43490	22,64323
Phase 2	Equal variances assumed	**,301**	,588	-1,343	26	,191	-10,53571	7,84230	-26,65579	5,58436
	Equal variances not assumed			-1,343	25,539	**,191**	-10,53571	7,84230	-26,66995	5,59852
Phase 3	Equal variances assumed	**1,286**	,269	-,373	22	,713	-3,55556	9,54510	-23,35087	16,23976
	Equal variances not assumed			-,358	15,018	**,725**	-3,55556	9,92089	-24,69928	17,58817

Table 2 compares the overall scores of the experimental and control groups. According to the table, a two-tailed paired samples t-test revealed that the experimental group scored higher points (m = 47,1800, s = 9,17499) compared to control group (m = 31,7667, s = 4,62667), t (3) = 2,030, p≤.05. In other words, the students in the experimental group have improved their scores (47,18 % versus 31,77 %) compared to the ones in the control group, by using the developed video game as an educational tool.

Table 2: Two-tailed paired samples t-test reveals that the experiment group scored higher points compared to control group

	Mean	N	Std. Deviation	Std. Error Mean
Experiment Group	47,1800	3	9,17499	5,29718
Control Group	31,7667	3	4,62667	2,67121

	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95 % Confidence Interval of the Difference				
				Lower	Upper			
Exp.Gr. Cnt.Gr.	15,41333	13,15159	7,59308	-17,25704	48,08370	2,030	2	,179

4 Conclusion

The research aimed to evaluate how the employment of an educational video game in education practice affects the learning of landscape grading topics. This educational video game differs from current teaching methods since it presents all theoretical information as three-dimensional models and assists students to fulfill the given learning tasks in real-world settings. Both groups have achieved sufficient success. However, the experimental group has 15 % more correct answers than the control group. The experimental results are encouraging with regard to the feasibility of the proposed video game into the undergraduate landscape architecture education practice.

Moreover, the findings obtained from the questionnaire highlight the motivational opportunities of the educational video game in learning.

The qualitative findings occur in three clauses. They are expressed below with some selected answers from the questionnaire:

1. The educational video game simplifies learning by blending the analog and digital methods:

- *"I think the virtual method of learning landscape construction was really effective, especially in combination with the drawing on the sheet."*
- *"It is good to see a 3d model of our 'paper area'. I can easily understand the plan and section of the area. Illustrated formulas are the best part of the game and questions about both formula and area helpfully solidify."*

2. It facilitates the understanding of complex concepts by representing the curriculum with visuals and three-dimensional models:

- *"I really like the idea of this project. The games supplied my dimensional analysis between contour lines and form of the landscape. Also they helped me to notice how our changes affected the area."*
- *"someone who is able to imagine the landforms in their mind, can see them in the game"*
- *"Seeing how the problems are resolved in the field."*

3. It increases the feasibility of developing a distance learning tool:

- *"Maybe not just quizzes in the class time, but also used with homework it might be able to solidify my learning"*
- *"Maybe more examples or homework"*

5 Future Works

This research presents standalone educational computer game software and the preliminary findings of a three-phased experimental study, to measure the motivational and educational effects on undergraduate landscape architecture students. Additional work is necessary to develop the educational video game based on the gathered feedback and integrating an online dashboard, to monitor the decisions made during the problem-solving process and to understand the learning patterns of students. In subsequent studies, the authors aim to develop the educational computer game in order to allow competitive and collaborative learning possibilities. Moreover, a learning management system could be integrated to monitor the learning levels and patterns of students.

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