Virtual Project-Based Simulation Games: Effectiveness in Construction Education of Different Genders

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Abstract
This paper reports on the results of testing a virtual project-based simulation game, called Skyscraper Simulator, in construction education. The results point to some interesting findings about different perceptions of learning gains between male and female participants. Skyscraper Simulator puts the players in a virtual construction environment and directs them from the beginning of building a skyscraper to the end. In this research study, the quantitative methods are used to measure the perception of construction learning gain. A retrospective pre and post playing perception of six main areas of construction knowledge, ability, and skills was used in a pilot test with 135 undergraduate construction students including 69 males and 66 females. The results indicate that there is a significant difference between the perception of participants in pre- and post- playing content knowledge, ability, and skills for all of the six construction main areas. Moreover, in 21 of 24 subareas, the difference between pre and post scores for female participants is higher than those of their male counterparts, which indicates that a virtual project-based simulation game like Skyscraper simulator is an effective tool for construction education at the undergraduate level, especially for female students.

Keywords: construction, education, gender, project-based, simulation

Introduction

Over the last few decades, gender issues in engineering education have been one of the controversial issues in academia. Using simulation games is one way to overcome the obstacles in engineering education. Since late 1950s until early 1970s, a lot of efforts have been made to facilitate learning by means of simulations and games. During recent years, simulations have been considerably used in education. In some areas like the medical field, simulations have been widely used and have shown significant advantages (Issenberg & Scalese, 2008; Kneebone, 2003). However using simulation in construction is not new, simulations were not widely used as a pedagogical method in construction education until 1990s. Since 50 years ago, simulations have progressed a little in construction (Nikolić, 2011; Rojas & Mukherjee, 2005, 2006; Sawhney, Mund, & Koczenasz, 2001; Veshosky & Egbers, 1991; Wall & Ahmed, 2008) whereas simulations which expose students to realistic experiences without real costs or risks are effective learning tools in construction education (Nikolić, 2011).

Methodology

The hypothesis of this research suggests that project-based simulation games such as Skyscraper Simulator can be an effective learning tool for both female and male construction students with limited education in construction. Skyscraper Simulator is a project-based game including animation which puts the players in a virtual construction environment and directs them from the beginning of a skyscraper construction project to the end. It guides the participants through a number of construction management using some help windows. Each decision the players make regarding equipment and personnel selection has an immediate effect on project cost and duration that are the criteria of project success. After the completion of game, the players complete a questionnaire in order to rate their retrospective pre- and post-playing perception of knowledge, ability and skills gained through playing the game. The construction content knowledge, ability and skills is defined in six major areas which are typical for their construction management curricula (Pariafsai, 2013) including construction stages and factors, estimation, machinery management, personnel management, ability and skills, and major steps in building a project. 135 undergraduate construction students, including 69 males and 66 females, successfully completed the test during spring 2016. Then, differences in perceived learning gain between male and female participants were measured. The two groups of participants were asked to rate their knowledge, ability, and skills before and after playing the simulation. A five-point Likert scale provided the following options: not at all, just a little, somewhat, a lot, and a great deal. The responses were separately analyzed for each gender using descriptive statistics including mean (μ), standard deviation (σ), and frequency. In order to compare differences in perceived learning gain of males with that of female participants, mean differences between pre-and-post playing scores were measured for each gender separately. Then, the self-reported evaluation data on each area were compared by means of a paired-samples T test.

Results

The results of the pilot test show that a virtual project-based simulation game like Skyscraper Simulator can be considered an effective construction education simulation for both male and female participants at the undergraduate level. Tables 1 to 6 show the difference between 69 male and 66 female students in each of the six main areas. The results indicate that there is a statistically significant difference between the retrospective pre and post playing perception of construction knowledge, ability and skills gained in all six areas for male and female undergraduate construction students.

Tables 7 to 12 show the percentage increase of the retrospective pre and post responses for male and female participants. This perception of change is higher in 21 of 24 subareas of all six areas for the female participants than indicated by their male counterparts.

Table 1: Results of Retrospection Perception of Knowledge Gain for the First Construction Knowledge Area

Experience	Area	Construction stages		Machinery		Personnel		Factors interactivity	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Female	Mean (μ)	2.818	3.879	2.652	3.818	2.591	3.636	2.136	3.530
	Stand. Dev. (σ)	0.9431	0.6909	0.8681	0.8211	0.8940	0.9709	0.7208	0.8269
	t-test (p<0.05)	Different		Different		Different		Different	
Male	Mean (μ)	3.029	4.072	3.072	4.000	2.667	3.812	2.536	3.783
	Stand. Dev. (σ)	0.9070	0.7340	0.9750	0.7670	0.8518	0.7529	0.9938	0.8201
	t-test (p<0.05)	Different		Different		Different		Different	

Table 2: Results of Retrospection Perception of Knowledge Gain for the Second Construction Knowledge Area

Experience	Area	Site costs		Machinery costs		Personnel costs		Capital management	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Female	Mean (μ)	1.985	3.455	1.894	3.242	2.091	3.455	1.773	3.167
	Stand. Dev. (σ)	0.7941	0.8626	0.8966	0.8604	0.7986	0.8073	0.7605	1.0013
	t-test (p<0.05)	Different		Different		Different		Different	
Male	Mean (μ)	2.275	3.696	2.304	3.609	2.710	3.797	2.290	3.551
	Stand. Dev. (σ)	0.9684	0.7134	1.0333	0.8947	1.0586	0.8674	1.0586	0.8834
	t-test (p<0.05)	Different		Different		Different		Different	

Table 3: Results of Retrospection Perception of Knowledge Gain for the Third Construction Knowledge Area

Experience	Area	Machinery provision		Optimum use of machinery		Machinery management duties		Machinery management goals	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Female	Mean (μ)	1.833	3.273	1.758	3.424	2.061	3.515	2.167	3.576
	Stand. Dev. (σ)	0.7562	0.9038	0.7857	0.8424	0.8749	0.9155	0.9213	0.9292
	t-test (p<0.05)	Different		Different		Different		Different	
Male	Mean (μ)	2.145	3.333	2.275	3.609	2.377	3.565	2.377	3.565
	Stand. Dev. (σ)	1.0329	0.9341	1.0694	0.9270	0.9564	0.9622	1.0860	1.0215
	t-test (p<0.05)	Different		Different		Different		Different	

Table 4: Results of Retrospection Perception of Knowledge Gain for the Fourth Construction Knowledge Area

Experience	Area	Personnel provision		Optimum use of personnel		Personnel management duties		Personnel management goals	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Female	Mean (μ)	2.061	3.348	2.045	3.439	2.212	3.652	2.258	3.545
	Stand. Dev. (σ)	0.8390	0.9363	0.8491	1.0688	0.8685	0.9999	0.9497	0.9637
	t-test (p<0.05)	Different		Different		Different		Different	
Male	Mean (μ)	2.420	3.696	2.478	3.681	2.623	3.754	2.580	3.754
	Stand. Dev. (σ)	0.8978	0.8796	0.9488	0.7572	1.0586	0.8472	1.1035	0.8813
	t-test (p<0.05)	Different		Different		Different		Different	

Table 5: Results of Retrospection Perception of Knowledge Gain for the Fifth Construction Knowledge Area

Experience	Area	Conditions analysis		Decision-making		Understanding project management concepts		Taking project manager responsibilities	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Female	Mean (μ)	2.091	3.621	2.485	4.076	2.227	3.727	2.470	3.909
	Stand. Dev. (σ)	0.8176	0.9075	0.9322	0.8649	0.9413	0.8329	1.2306	0.9880
	t-test (p<0.05)	Different		Different		Different		Different	
Male	Mean (μ)	2.348	3.609	2.551	3.913	2.565	3.826	2.826	4.116
	Stand. Dev. (σ)	0.9522	0.8440	1.0646	0.7996	1.0776	0.8217	1.2597	0.7959
	t-test (p<0.05)	Different		Different		Different		Different	

Table 6: Results of Retrospection Perception of Knowledge Gain for the Sixth Construction Knowledge Area

Experience	Area	Excavation basic principles		Foundation construction basic principles		Steel structure erection basic principles		Concrete floor construction basic principles	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Female	Mean (μ)	2.636	4.000	2.636	3.985	2.485	3.803	2.318	3.545
	Stand. Dev. (σ)	1.0761	0.9115	1.0323	0.9526	1.0988	0.9957	1.0101	0.9312
	t-test (p<0.05)	Different		Different		Different		Different	
Male	Mean (μ)	2.957	4.116	2.928	4.000	2.855	3.942	2.812	3.913
	Stand. Dev. (σ)	0.9917	0.6974	0.9598	0.8225	1.1018	0.8555	1.1018	0.8868
	t-test (p<0.05)	Different		Different		Different		Different	

Table 7: Percentage Increase in Retrospection Perception of Knowledge Gain for the 1rst Construction Area

	Area	Construction stages	Machinery	Personnel	Factors interactivity
Increase from Pre to Post Scores (%)	Female	106.06	116.67	104.55	139.4
	Male	104.35	92.75	114.49	124.64
Female / Male		1.02	1.26	0.91	1.12

Table 8: Percentage Increase in Retrospection Perception of Knowledge Gain for the 2nd Construction Area

	Area	Site costs	Machinery costs	Personnel costs	Capital management
Increase from Pre to Post Scores (%)	Female	147	134.85	136.36	139.39
	Male	142.03	130.44	108.7	282.61
Female / Male		1.03	1.03	1.25	0.49

Table 9: Percentage Increase in Retrospection Perception of Knowledge Gain for the 3rd Construction Area

	Area	Machinery provision	Optimum use of machinery	Machinery management duties	Machinery management goals
Increase from Pre to Post Scores (%)	Female	143.94	166.67	145.46	140.91
	Male	118.84	133.33	118.84	118.84
Female / Male		1.21	1.25	1.22	1.19

Table 10: Percentage Increase in Retrospection Perception of Knowledge Gain for the 4th Construction Area

	Area	Personnel provision	Optimum use of personnel	Personnel management duties	Personnel management goals
Increase from Pre to Post Scores (%)	Female	128.79	139.39	143.94	128.79
	Male	127.54	120.29	113.04	117.39
Female / Male		1,01	1.16	1.27	1.1

Table 11: Percentage Increase in Retrospection Perception of Knowledge Gain for the 5th Construction Area

	Area	Conditions analysis	Decision-making	Understanding project management concepts	Taking project manager responsibilities
Increase from Pre to Post Scores (%)	Female	60.61	159.09	150	143.94
	Male	126.09	136.23	126.09	128.99
Female / Male		0.48	1.17	1.19	1.12

Table 12: Percentage Increase in Retrospection Perception of Knowledge Gain for the 6th Construction Area

	Area	Excavation basic principles	Foundation construction basic principles	Steel structure erection basic principles	Concrete floor construction basic principles
Increase from Pre to Post Scores (%)	Female	136.36	134.85	131.82	122.73
	Male	115.94	107.25	108.7	110.15
Female / Male		1.18	1.26	1.21	1.11

The results of the pilot test show that project-based simulation games such as Skyscraper Simulator can provide an effective learning environment for students of both genders with limited education in construction. However, it can be considered more useful for females since the perception of change was bigger in 87.5% of all subareas for the female participants than indicated by their male counterparts.

Conclusion

The results of this research study indicate that Skyscraper Simulator as a virtual project-based simulation game developed perceived construction content knowledge, ability and skills of both genders. In addition, it showed that in 87.5% of all subareas, the female participants rated their learning gain higher than their male counterparts. According to the results of this investigation, virtual project-based simulation games like Skyscraper Simulator can be used as a new educational tool for construction education. Although more research is needed, this investigation indicates that such games could be a more successful alternate for female students in construction education.

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