© Nottingham University Press
Proceedings of the International Conference on Computing in Civil and Building Engineering
W Tizani (Editor)

Impact of gaming application use in construction engineering education

Elizabeth Howard & Clark Cory
Purdue University, Department of Computer Graphics Technology, West Lafayette, USA
Hazar Dibb
Purdue University, Department of Computer Graphics Technology, West Lafayette, USA

Abstract

Traditional construction engineering education focuses on text-based learning utilizing well-defined construction problem scenarios, theories and principles. Other research states that concepts have historically been taught as independent theory and segmented classroom activities, which have not always reflected potential real-world, industrial scenarios. Popular learning methodologies suggest these traditional educational methods separate the learner from the learning context. In industry, students are expected to apply text-based theories to real-world scenarios, and through the current educational methods, students lack the required critical hands-on, problem-solving skills needed to handle industry situations. Case-studies and site visits would provide students with the necessary exposure to industry situation. However, availability of such opportunities, safety concerns, lack of resources, and feasibility of class size prevents frequent field visits. Simulated game environments can be utilized as educational resources to build the real-time, problem-solving abilities of students. These simulated game environments, adapted to mimic real-world construction scenarios and processes, allow students the opportunity to study the responses of the simulation as it reacts to their inputs and decisions. These new educational methods challenge students to employ theories, principles, and real-time, problem-solving skills when immersed in game play.

Keywords: Engineering education, serious games, gaming

1 Introduction

Engineering education is now seeing the impact of a new generation of students known as the Millennial generation. The Millennial generation is unique in the fact that it possesses new and different characteristic from that of previous generations. These characteristics of Millennials not only shape their personas but they also form the distinctive learning preferences of this generation (Shaw and Fairhurst, 2008). These learning preferences clash with traditional teaching methods still employed in engineering education today. Though the curriculum is evolving to incorporate the ever increasing volume of data and skills needed to compete in today's environment, traditional teaching styles have yet to mold to fit today's student.

It is recognized among teachers and researchers that games can inherently provide valuable skills such as strategic thinking, planning, communicating, negotiating, decision-making and data handling (Kirriemuir and McFarlane, 2004). The use of serious gaming in construction engineering education could offer a supplementary tool for allowing students to interact with environments, materials and

personnel applying the knowledge learned from traditional learning methods. Gaming could act as a simulation for real-world experience helping to bridge the gap between concept and application.

2 Defining today' student

A new generation of students, known as the Millennial Generation, is now entering the age of higher education. This generation, also known as the Internet Generation, Echo Boomers, the Boomlet, Nesters, Generation Y, the Nintendo Generation and the Digital Generation, refers to individuals born between the years of 1982 and 2000 (Shaw and Fairhurst, 2008). Millennials have grown up in a world consumed with technology and their use of technology in daily life exceeds that of previous generations. They are defined as the most diverse generation our country has ever seen. Millennials have a strong sense of community and high moral values. They are described as social, confident, educated, team-oriented, accepting, and achievement oriented (Jonas-Dwyer and Pospisil, 2004; Oblinger, 2003).

Jason Frand (Oblinger, 2003) has defined several traits characteristic of the Millennials Generation. For Millennials, computers have become a way of life and are no longer considered a form of technology. They place importance on results and actions rather than knowledge. Millennials thrive on multi-tasking. They can listen to music and text on their mobile phone all while typing papers on the computer. It is essential for them to stay connected to friends, family, news, and the Internet via a variety of electronic devices. Constant connection and reliance on computers account for the Millennials' lack of tolerance for delay. They expect instant feedback and constant connection.

Oblinger and Brown (Jonas-Dwyer and Pospisil, 2004) identify Millennials to prefer teamwork, experiential activities, structure, and use of latest technology in their learning engagement. Traditional instructivist methods of teaching focusing on textbook and lecture format are un-motivating to this generation (Annetta et al., 2006; Foreman, 2003). Instead, Frand (Oblinger, 2003) describes the learning style of Millennials to more closely resemble Nintendo than traditional logic. Millennials prefer a trial-and-error approach to learning that mimics game logic. Understanding and knowledge is gained by both winning and losing in a game. This learning preference ties in closely to Millennials preferring experiential activities.

3 Games as educational tools

Video games are an important part of today's culture. Game play mimics the use of technology students expect in learning. It is fast pace and provides instant activity and response. The desire to harness the motivational power of games and the belief in "learning through doing" in game play are two key themes in the development of games for education (Kirriemuir and McFarlane, 2004). Marc Prensky (Rankin and Vargas, 2008), known for his contemporary writing, inventing, and game design, states that learning and game play are becoming synonymous with each other through the development, spread, and use of games in the classroom.

3.1 Defining serious games

The term "serious game" can be used to describe a broad range of educational gaming applications included for use in education, business, healthcare, government, and military. Pinpointing the exact definition of the term is difficult since it is used to define a genre of games across multiple industries. Although there is a range of definitions used for serious games, all hold the core belief that serious games are used for the purpose of learning and instruction and not for pure entertainment purposes. Common uses of serious games include training, simulation and/or education, and utilize the power of

computer games to engage and motivate players with the purpose of building knowledge and developing new skills (Annetta et al., 2006; Rankin and Vargas, 2008; Susi et al., 2007).

Serious games can be divided into subsets of gaming styles each supporting different types of learning and activities (Prensky, 2001). Strategy games, skill games, adventure games, training games, and simulation games are among a few of the more popular game styles (Rankin & Vargas, 2008).

3.2 Simulation games

Simulation games are defined as games in which players immerse themselves into a simulated environment and interact with their surroundings (Kirriemuir and McFarlane, 2004). They support learning activities such as understanding principles, graduated tasks, and playing in micro worlds (Prensky, 2001). Laurel (1991) writes that educational simulations, opposed to traditional tutorial and repetition forms of instruction, excel because they represent experience. Learning through doing has been demonstrative to be more effective and fun than traditional instruction. Simulation games (Rankin and Vargas, 2008) are a great alternative for when real-world activities are dangerous or not accessible for classroom learning. They offer players the opportunity to test and reinforce theory learned in the classroom applying this knowledge in a semi-realistic setting (Nassar, 2002). Simulation style games can provide exposure to scenarios to help students prepare for industry roles.

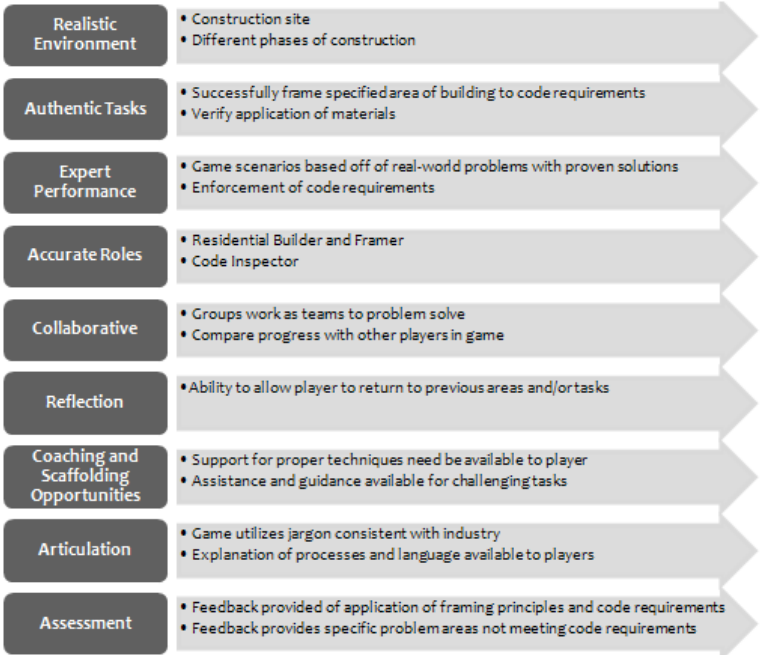

Figure 1. Example of key characteristics indicative of successful learning environments applied within a fictitious construction graphics game.

Simulation games can mimic real-world experiences and place players in defined roles within these environments. Gredler, according to Harper, Squires & McDougall (2001), defines four key components of experiential simulation. First, the scenario should reveal a complex task or problem in context of the player's actions. This component ties into constructivism with the presence of puzzlement to stimulate the player (Kirkley and Kirkley, 2005). The next component requires the player takes on a defined role in scenario and executes responsibilities of the position. This provides the player the opportunity to investigate the scenario from a role perspective and apply knowledge within the context of that role (Herrington and Standen, 2001). The third component calls for the simulation to allow for multiple decisions and paths throughout game play. This provides freedom of exploration and experimentation for the player. Finally, the player is in control of decision making and deciding his or her own path throughout game play.

4 Traditional teaching methods in construction engineering education

Traditional methods of construction education (Rojas and Mukherjee, 2005a, 2005b) have primarily focused on well-defined problem scenarios and the study of theories and practices. The content delivery of this knowledge in higher education has primarily been through textbook, illustrations and images and 2-dimensional project drawings and is often taught as independent concepts in the lecture based format. This method of teaching reflects an instructivist environment (Herrington and Standen, 2001). These methods separate the learner from the learning context (Rankin and Vargas, 2008; Rojas and Mukherjee, 2005a, 2005b). Furthermore, classroom activities do not always reflect real-world scenarios thus making it difficult for students to recall theories and apply them in proper context when encountering real-world applications found in industry.

Traditional teaching methods lack real-world experience and application of construction principles and theories. Ideally, case studies and site visits would offer excellent exposure to real-world scenarios. Russell, Hanna, Bank and Shapira (2007) discuss the importance of real-world experience to aid in education. It is believed that real-world experiences enhance learning by providing realistic applications of industry problems, challenges and solutions. These experiences help students connect classroom learning with industry applications. Russell et al. continue that such experiences spark ideas for innovation within students. Experience provides opportunities for students to communicate with industry professionals learning industry jargon and practices as well as offer various perspectives of the industry not always revealed in traditional teaching methods. However, availability of such opportunities, safety concerns, lack of resources and feasibility prevent frequent, if any, visits (Rojas and Mukherjee, 2005b).

In order for today's students to become proficient in the field of construction engineering, students need to understand basic theories and principles to visualize, apply, and communicate them accurately in drawings, details, and building information models. Learning theories and their appropriate application often do not go hand-in-hand. An additional tool is needed to assist with visualization and understanding of such concepts. Serious games, designed accordingly, could offer a supplementary tool for allowing students to interact with environments, materials and personnel applying the knowledge learned from traditional teaching methods. These games could act as simulations for real-world experience helping to bridge the gap between theory and application.

5 Success of gaming in related disciplines

As serious games begin to become more accepted for use in education, few disciplines have yet to embrace them as learning tools. However, successful games have been developed and implemented in the related discipline of Construction Engineering and Management (CEM) (Rojas & Mukherjee, 2005b). Simulation style games are becoming more popular within engineering education and the field of CEM (Nassar, 2002), in particular, has seen the development of several such games like VIRCON (Jaafari et al., 2001), Construction Management Game, CONSTRUCTO, Superbid, Negotiation Game, and the Lego Bridge Game. These games, designed to enhance students' knowledge and understanding of bidding and construction management processes, also build valuable decision-making abilities and develop industry-related skill sets (Nassar, 2002; Rojas and Mukherjee, 2005a, 2005b).

VIRCON, short for Virtual Construction (Jaarari et al., 2001) and designed for the purpose to improve visualization capability, serves as a planning and visualization tool for construction plans. It is used by universities as both a planning and teaching tool within the field of CEM. This system allows students to simulate diverse scenarios for exploration and experience in problem solving within construction management. It also provides access to additional educational materials via the Internet to support self-pace learning. A study conducted by Jaarari, Manivong and Chaaya (2001) reveals the success of integrating VIRCON into academia as a method for teaching the construction management

process. The use of VIRCON in this study replaces traditional instructivist methods of teaching and utilizes the visualization and experiential strengths of the game environment to teach theory. This use of simulation used for education is reflective of the constructivist learning theory discussed later in this review.

Another simulation game, SuperBid, developed at the University of Alberta, is a simulation model that mimics the construction bidding process in particular (Nassar, 2002; NSERC/Alberta Construction Industry, Research Chair, 2006). This game is designed to improve skills expected of construction managers working within the competitive industry. Players, students, encounter scenarios in the game format where they compete with other players to provide best bidding practices and highest return on investment to "win" the game (NSERC/Alberta Construction Industry, Research Chair, 2006). Game play mimics the competition students will encounter in industry providing valuable experience otherwise not available to them through traditional educational methods.

6 Learning methodologies applied in gaming

Constructivist and situated learning theories have become popular perspectives for learning environment design within serious games. These theories focus on the learner's activities and goals while immersed in a simulated environment and how the learner constructs knowledge through his or her response and experience in the context of the environment and situation they are playing (Kirkley and Kirkley, 2005). It is through the use of these learning methodologies applied in the design of serious games that make them effective educational tools.

Blending these principles into the creation of multimedia learning environments and simulation games is becoming more popular. Constructivist applications (Herrington and Standen, 2001) have many advantages over traditional instructivist methods of teaching which mimic the textbook and lecture model. They are able to shine light on the relevance of theory to application and help to provide realistic experiences that are closer to industry scenarios than traditional classroom activities.

Learning environments (Kirkley and Kirkley, 2005), such as previously discussed serious games, should be developed to allow learners to use the technology in a way to help them achieve their learning goals. In other words, these environments should be designed with the proper learning models in place that support learning and not just developed for the sake of entertainment. Situated learning and constructivist theories place the emphasis on learning through "understanding via purposeful interaction with the environment, including cognitively authentic context, content, and activities that are meaningful to the learner" (Kirkley and Kirkley, 2005, p. 45) . When designed accordingly, serious games offer the ability to provide simulated experiences linking theory and application which create opportunities for learning development. Use of gaming in this manner provides exposure to scenarios to help prepare students for industry roles.

7 Concluding thoughts

Today's students, known as the Millennials, have grown up in a world consumed with technology and their use of technology in daily life exceeds that of previous generations. For them, computers have become a way of life and are no longer considered a form of technology. They prefer teamwork, experiential activities, structure and use of latest technology in their learning engagement (Jonas-Dwyer and Pospisil, 2004). Millennials take a trial-and-error approach to learning that mimics game logic (Oblinger, 2003). Traditional teaching methods are un-motivating to this generation and therefore new approaches need to be reviewed.

Traditional construction engineering education methods separate the learner from the learning context and often do not provide for application of theory (Rankin and Vargas, 2008; Rojas and Mukherjee, 2005a, 2005b). Currently, there exists a need for an additional tool to assist with

visualization and understanding of such concepts to ensure thorough comprehension among students. Here is where serious games can be utilized to fill the void in construction engineering education. Serious games mimic real-world construction scenarios and processes and challenge student to employ their knowledge of theories and principles to bridge the gap between theory and application. Successful usage of serious gaming can be seen in the construction engineering and management field. Such gaming applications need further study to see what aspects can be applied to construction engineering education.

References

ANNETTA, L.A., MURRAY, M.R., LAIRD, S.G., BOHR, S.C., and PARK, J.C. 2006. Serious Games: Incorporating Video Games in the Classroom. *EDUCAUSE Quarterly*: EQ. 29 (3), 16-23.

FOREMAN, J. 2003. Next-Generation Educational Technology versus the Lecture. *EDUCAUSE Review*. 38 (4), 12-16,18,20-22.

HARPER, B., SQUIRES, D., and MCDOUGALL, A. 2000. Constructivist simulations: a new design paradigm. *Journal of Educational Multimedia and Hypermedia.* 9 (2), 115-130.

HERRINGTON, J., and STANDEN, P. 2001. Moving from an instructivist to a constructivist multimedia learning environment. *Educational Administration Abstracts*. 36 (3), 275-408.

JAAFARI, A., MANIVONG, K.K., and CHAAYA, M. 2001. VIRCON: Interactive System for Teaching Construction Management. *Journal of Construction Engineering and Managemen*t, 127, 66-75.

JONAS-DWYER, D. and POSPISIL, R. 2004. The Millennial effect: Implications for academic development. Transforming Knowledge into Wisdom: Holistic Approaches to Teaching and Learning, HERDSA 2004 Conference Proceedings (p. 195-207).

KIRKLEY, S.E., and KIRKLEY, J.R. 2005. Creating Next Generation Blended Learning Environments Using Mixed Reality, Video Games & Simulations. *Tech Trends*, 49 (3), 42-53.

KIRRIEMUIR, J. and MCFARLANE, A. 2004. Literature Review in Games and Learning. Futurelab Series Research Report No. 8.

LAUREL, B. 1991. *Computers as Theatre*. Reading, MA: Addison-Wesley Pub.

NASSAR, K. 2002. Simulation Gaming in Construction: ER, The Equipment Replacement Game. *Journal of Construction Education,* 7 (1), 16-30.

NSERC/Alberta Construction Industry, Research Chair. (2006, January 9). *SuperBid: Simulation of Construction Bidding.* Retrieved March 24, 2009, from http://irc.construction.ualberta.ca/html/research/SuperBid.html

OBLINGER, D. 2003. Boomers, Gen-Xers, and Millennials: Understanding the New Students. *EDUCAUSE Review*, 38 (4), 36-40,42,44-45.

PRENSKY, M. 2001. *Types of learning and possible game styles*. Digital Game-Based Learning. Available at: http://www.marcprensky.com/writing/Prensky%20%20Types%20of%20Learning%20and%20Possible%20Game%20Styles.pdf

SHAW, S., and FAIRHURST, D. 2008. Engaging a New Generation of Graduates. *Education & Training*. 50 (5), 366-378.

SUSI, T., JOHANNESSON, M., and BACKLUND, P. 2007. Serious games - an overview. Technical Report HS-IKI-TR-07-001, School of Humanities and Informatics, University of Skovde, Sweden.

RANKIN, J.R., and VARGAS, S.S. 2008. A Review of Serious Games and other Game Categories for Education. SimTect2008 Conference Proceedings, Melbourne Australia, 2008

ROJAS, E.M., and MUKHERHEE, A. 2005a. Interval Temporal Logic in General-Purpose Situational Simulations. *Journal of Computing in Civil Engineerin*g, 19 (1), 83.

ROJAS, E.M., and MUKHERHEE, A. 2005b. General-Purpose Situational Simulation Environment for Construction Education. *Journal of Construction Engineering and Management,* 131 (3), 319.

RUSSELL, J.S., HANNA, A., BANK, L.C., & SHAPIRA, A. 2007. Education in Construction Engineering and Management Built on Tradition: Blueprint for Tomorrow. *Journal of Construction Engineering and Management,* 133 (9), 661-668.