CONSTRUCTION EDUCATIONAL GAME FOR K-12

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ABSTRACT: The future competitiveness of construction industry is dependent on K-12 students. However, unfavorable images of construction industry have negative influence on K-12 students' decision-making of their career. This negative image makes them not want to find out what actually happens in construction industry. Consequently, it is important to give K-12 students the opportunity to know what construction employees actually do in their job. Studies show that K-12 students who encounter the job early-on are more likely to choose it as their career. In this context, this paper proposes construction educational game in which it can serve as a medium for capturing K-12 students' interest in Construction Management (CM). Based on the literature reviews, challenges of construction educational game for K-12 students which are edutainment, hands-on experience and social interaction, are derived. To address these issues, conceptual model and scenario are designed. Based on designed scenario, prototype of Simulation based Construction Game in Virtual World (SCGVW) is developed in *Second Life (SL)* and applicability test to K-12 students are implemented. This paper concludes with a discussion of the lessons learned and the future development steps of the construction educational game for K-12 students.

Keywords: Educational game, K-12 students, Construction management, Simulation, Virtual world

1. INTRODUCTION

Construction industry contributes greatly to the national economy. In case of Korea, construction investment accounted for 16.6% of GDP (2010) and construction industry employed about 7.2 % of all workers (2011). Nevertheless, construction industry images are still negative as dangerous, physically demanding and macho, bricklaying, site work and physical labor (Ginige et al. 2007). One of the serious problems of poor image is a negative influence on career decision-making (Rosenthal 1990) in construction industry. This phenomenon would result in lacking of skilled labor and professional in foreseeable future.

Image is mental picture and is built through a combination of both information gained from the environment and relevant past experience. The negative image makes both men and women reluctant or uninterested in the industry (Harris 1989) because image determines an attitude and behavior of people. Furthermore, the unfavorable image of the industry is strong enough to restrict people seeking the reality beyond it (Ginige et al. 2007). Unawareness about construction industry aggravates negative impressions.

The key to the solution of the problem of image is 'education' (Fiori 2003), particularly for the kindergarten through twelfth grade (K-12). The future competitiveness of any country is dependent on K-12 students' educational system developing K-12 students' talents in construction and encouraging their interest in these areas. Studies show that if K-12 students encounter engineering early in school, they are more likely to choose it as a career (Selingo 2007). This is therefore viewed as an important period because they can take advantage of the teacher's academic model.

However, many K-12 teachers have no idea what construction employees actually do and how to teach construction industry to K-12 students. In addition, construction educational environment for K-12 is inadequate. In order to fully understand fundamental and soft skills, it is essential that students visit construction sites during their education (Wilkins and Barrett 2000). However, it is restricted in time and scope due to the special nature of construction operations, where any small mistake could result in serious technical, financial, or safety results.

To overcome these barriers, this research suggests construction educational tool which can educate K-12 students without visiting construction sites and schoolteacher. Educators have been intrigued with the potential of technology to help transform education and improve students learning. Studies in education demonstrate that the use of technology can help improve students' scores on standardized test, improve students'

inventive thinking. K-12 students are referred to 'game generation', who has a cognitive characterized by multitasking while learning, short attention span during learning, and an exploratory and discovery approach to learning (Asakawa and Gilbert 2003, Bain and Newton 2003). A study on 7-16 years old students in the UK showed that most of them were regularly domestic game player (McFarlane et al. 2002).

Therefore, the use of educational game is one way that has been shown to be effective for improving K-12 education (Prensky, 2001). Motivations of games could be combined with curricular contents. Learning is an active process which requires conscious and deliberate effort, thus motivation is related with learning (Bruner, 1960; Wlodkowski, 1986). Self-motivated students are shown to perform better in education. In terms of motivating the K-12 students' learning as well as serving as a medium for capturing students' interest in a specific subject area, educational game's potential to support K-12 education is argued. In this context, this research aims to develop construction educational game for K-12 which can let K-12 students know about construction management (CM) and career opportunities with interest.

2. CHALLENGES OF CONSTRUCTION EDUCATIONAL GAME FOR K-12

In the field of construction education, educational game has been developed and utilized. However, they were targeted at the person who already entered in construction industry. In this chapter, we have derived three challenges of designing construction educational game for K-12 students.

2.1 Design to be edutainment

The use of educational game is the effective way for motivating K-12 to learn. Previous research suggest attributes of games that make students motivating and entertaining include fun, stimulated curiosity, fantasy elements, clear objectives, and challenge (Koster 2005, Tews 2001, Wolf 2001, Miller 2005). The entertainment attributes of educational game have been used to motivate K-12 students to participate in the learning activity. However, if educational game is designed principally for entertainment, with presumed little regard for any designed instructional goal to support K-12 students learning activities in formal educational setting, students may become the focus of the entertainment or a distraction from the learning activity. The downside of this approach has been the much of the substantial learning that is reported is secondary or unintentional (Kiriemuir 2002, Hayes 2002). On the other hand, if educational game is specifically designed for learning but either lack entertainment attributes associates with high levels of motivation or contain overwhelming levels of game-like attributes, it ultimately results in distracting the K-12 students from the learning objectives. Accordingly, it should be addressed to balance between entertainment purpose and educational purpose. In other words, scenario of construction game should design to be edutainment, a form of entertainment designed to educate as well as to amuse.

2.2 Design K-12 to do hands-on experience

Construction education curriculum has historically placed an emphasis on hands-on experience. Learning through hands-on, minds-on activities can help K-12 students develop these skills. Research has shown that students benefit from a learning environment that allows them to exercise control over their learning experiences and that requires them to be responsible for their own learning performances (Tenenbaum et al., 2001). In addition, learning that occurs in a real context is readily transferable to the real world and is likely to be well-integrated into the students' existing knowledge network. Learning about being a construction manager and learning to become a construction manager are two very different things. In doing so, students look at occurrences from different perspectives as well as experience and understand problem situations from different point of view. Learning about something is limited to gaining information, whereas learning to become something requires both information and experience (Brown and Duguid 1998). By allowing students to think, speak, and act on issues from the perspective of a unique persona, it is intended that they will engage more effectively in critical thinking and argumentation related to the topic of concern. (Jamaludin et al. 2009). This situating learning in an authentic context is referred to as situated cognition. Knowledge obtained from real context is much more likely to be relevant to the students than if they were solving the same problem represented in a worksheet (Harmon, 2008). Therefore, construction educational game should design K-12 students to put situation by becoming something such as construction manager, engineer and foreman.

2.3 Design K-12 to learn by social interaction

In teaching-learning process, learning occurs in social contexts through dynamic interaction with teachers, peers, and content. Certainly, one can learn alone, but learning may be more efficient when done collaboratively. Effective collaboration with peers has proven itself a successful and uniquely powerful learning method (Brown and palincsar, 1999). The most effective instructors teach K-12 students both the cognitive skills necessary to learn the subject matter, and the social skills they need to communicate well in a team (Soller 2001). The social basis for learning theory, social constructivism has been acknowledged since the seminal research of the Russian psychologist Vygotsky (1978). Social constructivism empathize the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding (Derry, 1999). However, placing students in a group and assigning them a task does not guarantee that the students will engage in effective collaborative learning behavior. In order to promote social knowledge construction, a learning environment must provide a variety of communication tools, such as synchronous (chat rooms and video conferencing) or asynchronous (discussion

forums and email) facilities (Wang 2009). In other words, construction game should design to be able to take actions to help K-12 students collaborate more effectively with their peers, maximizing individual students and group learning.

3. DESIGNING OF CONSTRUCTION EDUCATIONAL GAME FOR K-12

To address three challenges described in section 2, we have proposed the conceptual model and designed the game scenarios. We name proposed construction educational game for K-12 as Simulation-based Construction Game in Virtual World (henceforth called SCGVW).

3.1 Designing conceptual model

Construction education needs to emphasize more on practical knowledge and efficient tools that will enhance the students' thinking, problem solving and interpersonal skills. We have developed conceptual model. Figure 1 shows concepts of SCGVW corresponding with derived three challenges.

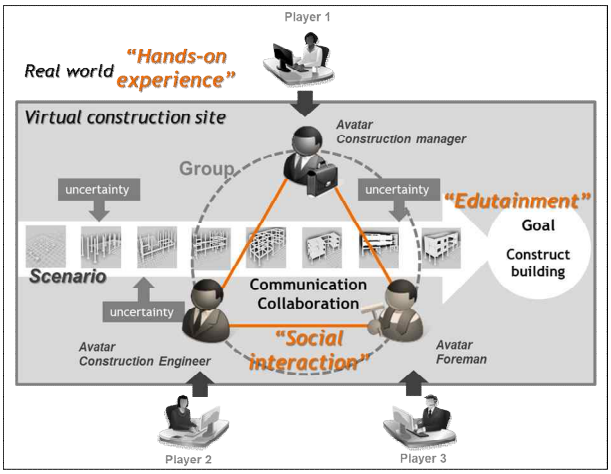

Figure 1. Conceptual model

(1) Avatars in virtual construction site

We have developed the virtual construction site in virtual world. Students who are in different places can access the same virtual construction site. In virtual construction site, there is no cost and no resource burden associated with building whatever one can conceive against students are limited by lack of access to the material, tools, and the know-how needed to create interesting and complex structures in the real world (Harmon 2008). Students can become avatars, who are construction employees. There are three characters who are foreman, construction engineer and construction manager and they have a different role. Foreman is a worker coordinator who is construction work with many years of experience in a trade who is charged with organizing the overall construction of a project and in charge of a construction crew. Construction engineer is a problem solver who has a strong understands of math and science, and many other skills as critical and analytical thinking, and good communication skills. Construction manager is a decision maker on construction procedures, methods, and people management. By becoming one of characters, they can contact with others in virtual construction site. By allowing students to be in character, it is intended that they will identify more strongly with the character whose role they enact.

(2) Building construction in uncertainty

The game goal is to construct a building on time, within budget, and of the desired quality and safety. It is reflected that the functions of CM which include schedule management, cost management, safety management and quality management. We use computer simulation in order to offer opportunities that students can experience construction activities which closely resemble actual construction process. In real world, unexpected situation such as bad weather conditions, workers absence can be happened. These uncertainties are designed in computer simulation. For example, sever rain influences on working day so that actual schedule is delayed than expected schedule. In this case, students may decide to increase number of workers and daily working hour in order to reduce the schedule gap. However, the much daily working hour increase, the more workers fatigued. It causes worker sickness absence.

Furthermore, we have designed building model. The most interesting aspect of game is the way that it provides constant visual feedback on the state of each construction phase. The progress of constructing a building depends on students' decisions. The building model grows when students come to a rational decision in uncertainties. This constantly growing building provides an interesting and very engaging kind of feedback. Bos (2005) had called this interaction 'organic feedback'. Interacting with game feels much like interacting with a growing organism, which is in some ways malleable, but also has a personality that are revealed only over time, and much of the pleasure derives from discovering this personality through interaction. By placing in designed scenarios, students are motivated to play game and they can learn both construction project management and the process of building construction.

(3) Collaborative construction work

The game is designed to three students participate in constructing a building together as a project team. A project team is comprised of three avatars, foreman, construction engineer and construction manager. By given them same goal which is to construct a building and assigned different authority to each avatar, students engage in collaborative learning behavior. If any of three students hasn't participated in decision-making processes together, it's difficult to achieve the final goal. For example, if student who has responsibility of workforce hires a lot of new workers without discussion, this arbitrary behavior leads to overspend labor cost and constructing a building would be failed finally. This designed group playing environment enables student to gain a better understand of construction by social interaction. Furthermore, virtual world we have utilized,

affords to face to face social interactions which form a communication channel particularly conductive to transfer of tacit, non-codified knowledge (Noorderhaven and Harzing, 2008). Students learning effectively in groups encourage each other to ask questions, explain and justify their opinion, articulate their reasoning, and elaborate and reflect upon their knowledge (Soller 2001).

3.2 Scenario description

The SCGVW developed in this research focuses on the CM aspects of building construction, not solid technical background but basic fundamental and soft skills. When playing the game, students should satisfy a target cost budget and adhere to a given project time duration, within allowed accidents and errors (i.e. during 20 week/ within $500,000/ below 250 errors and 5 accidents). It emphasizes the importance of monitoring cost, time, safe and quality of project during constructing a building. Students should check not only the value of result valuables which are in the field of schedule, cost, quality and safety management but also the value of worker fatigue, productivity, number of workers which are cause variables. The SCGVW scenario sequence is illustrated in Figure 2.

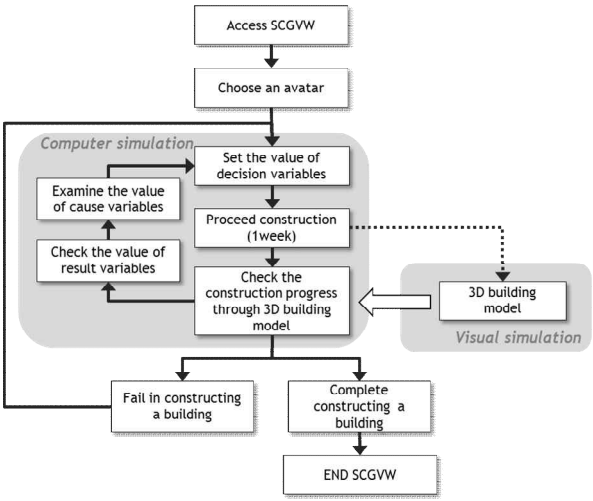

Figure 2. Scenario sequence

First of all, three students access SCGVW and choose one avatar among a foreman, a construction engineer and a construction manager. Each avatar can make one decision during constructing. There are three kinds of variables which are decision variables, cause variables and result variables as shown in Figure 3. K-12 students can control decision variables which influence cause variables and results variables. A foreman avatar can make a decision regarding 'number of hiring new workers', a construction engineer avatar can do regarding 'degree of checking thoroughness', and a construction manager avatar can do regarding 'daily working hour'. After K-12 students set the value of decision variable individually and advance one week construction, the 3D building model would be imported as much as construction progress. At this time, in order to complete constructing a building within predetermined conditions, K-12 students should check the value of result variables and examine the value of cause variables. Through repetitive discussion of decision making, K-12 students can achieve game goal. If construction is delayed than scheduled or construction cost overspends, game would be over and K-12 students should restart.

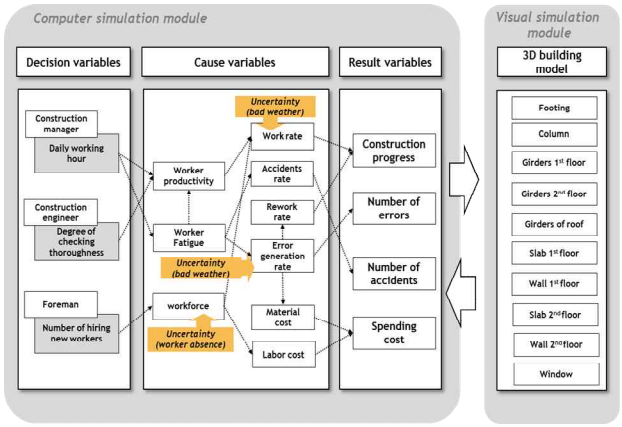

Figure 3. Scenario map

Figure 3 illustrates the scenario map of the SCGVW. As shown in computer simulation module of scenario map, K-12 students' decision on value of decision variables influence on value of cause variables and results variables. In order to increase the work rate, worker productivity and workforce need to be considered. The value of these variables depends on daily working hour, degree of checking thoroughness, and number of hiring new workers. This means that foreman, construction engineer and construction manager need to communicate and adjust the value of decision variables. Computer simulation module and visual simulation module interact each other. For example, if construction progress is 10%, footing of building would be imported in virtual construction site. K-12 students can see the building construction process and check construction progress through visual simulation module. If K-12 students fail to control number of errors, 3D building model would not react.

As suggested in conceptual model, unexpected conditions are designed. In construction project, dealing with unexpected conditions are a prerequisite management skill. Unexpected conditions, in other words, uncertainties are generally divided into two parts which caused climate and human factors. The bad weather (i.e rain, severe temperature, disaster etc.) triggered randomly causes shut-down construction site or error generation. With regard to human factors, worker absence influence on workforce which plays an important role in construction. Thus, K-12 students must make a decision immediately when they faced with uncertainty scenario. Based on the designed scenario, K-12 students set the value of decision variable, proceed construction, check construction progress and examine the value of cause variables continuously until a building construction complete. Through this repetitive process, K-12 students can share their knowledge and learn management skill and interpersonal skill in construction process.

4. SIMULATION-BASED CONSTRUCTION GAME IN VIRTUAL WORDL (SCGVW)

In this section, we have developed prototype SCGVW. And applicability test is carried out. SCGVW utilizes interactive and immersive functionalities of virtual world environments and computer and visual simulation model that represent construction systems in the real world.

4.1 SCGVW development

We develop prototype of SCGVW in *Second Life (SL)* platform which have the potential to address the communication issues and effectively complement traditional teaching approaches. *SL* is an internet-based immersive virtual world developed by Linden Lab that enables its users, called 'residents', to interact with each other through motional avatars, providing an advanced level of a social network service combined with general aspects of a met-averse. Nederveen (2007) discusses the possibilities of *SL* for collaborative architectural design focusing on the many virtual complex constructions that have already been collaboratively created within *SL*. For developing SCGVW in *SL,* we have implemented four steps as follows.

The 1st step is to acquire an empty island in SL and create the virtual construction site. We decorate construction site and create employment objects that avatars can become foreman, construction engineer or construction manager when avatars gain these objects. The 2nd step is to develop 3D building model using AC3D and to install AC3D models in SL. The AC3D software interface is similar to standard 3D modeling software. It allows rather efficient modeling compared to SL modeling and produces an acceptable file format to export to SL (Ku and Mahabaleshwarkar, 2011). We draw two-story AC3D building models in order of construction process. It is exported AC3D models as FILE.SLB using SL boxes plugin and opened in Notepad. After getting AC3D box creator from *SL* exchange, it has been replaced geometrical properties of AC3D box with Notepad File. The 3rd step is to make computer simulation model and to create user interface of simulation panel in *SL*. A System Dynamics (SD) modeling approach is well suited to deal with the dynamic complexity of construction projects, as demonstrated by researcher (Ng et al., 1998, Peña-Mora and Park, 2001). Based on developed SD model, we have built user interface consisted of control slides of decision variables in simulation panel. When avatars change the value of decision variables in simulation panel, it is stored at SD database and the changes are reflected in simulation panel. The 4th step is to link SD database with AC3D box creator which is medium of importing 3D building model. In *SL*, we use the Linden Scripting Language (LSL) as programing interface to control the behavior of an avatar and to add functionality to objects. However, LSL contains many limitations for the end user to linkage with other data files. We had difficulties to make the functionality of generating AC3D box creator automatically according to the value of construction progress. Therefore, we substitute them for manually operated. When avatar touches AC3D creator, it would start importing 3D building model. User interface of SCGVW is shown in Figure 4.

Figue 4. Screenshot of SCGVW

4.2 Applicability test

The SCGVW was tested by twenty one high school students belonging to Cupertino High School in U.S. The purpose of test was not merely to identify the purposiveness of SCGVW but also to investigate the effectiveness of SCGVW. Construction knowledge in K-12 students' need was investigated as well. Applicability test was conducted three sections, lasting about 20 minutes each. Firstly, K-12 students were asked to complete first questionnaires which were consisted of questions about the purposiveness of SCGVW. The impression about the construction industry, their interest in construction industry as a job and their knowledge level about construction industry were asked. And then, we explained how to use the SCGVW according to scenario sequences as shown in Figure 2. After an abridged description, K-12 students asked to play the SCGVW until they achieve the game goal. Finally, after completion of game play, K-12 students were requested to answer the second questionnaires. The second questionnaires include not only first questionnaires but also questions about the effective and interesting learning behaviors, and construction knowledge that K-12 students want to know.

Table 1. Results of purposiveness

	Q-A	Q-B	Q-C
before	3.29	2 (10)	109 (65)
after	3.53	5 (24)	128 (76)
variation	+0.24	+3 (14)	+19 (11)

Q-A: Impression about the construction (point)
Q-B: Construction as future career (person, %)
Q-C: Construction knowledge (point, %)

Table 2. Results of K-12 students' behavior analysis

	Q-D	Q-E
role-playing	8 (38)	9 (43)
visualization	8 (38)	5 (24)
decision-making	5 (24)	6 (29)
total	21 (100)	21 (100)

Q-D: effective behavior to understand construction (person, %)
Q-E: interesting behavior to motivate to do (person, %)

Table 3. Results of K-12 students' needs

	Q-F
the process of constructing a building	8 (38)
the task of construction employees	1 (5)
the factors that are needed to construct a building	10 (48)
etc.	2 (9)
total	21 (100)

Q-F: knowledge K-12 students want to know (person, %)

The results of the applicability test present in table 1, 2, and 3. Table 1 shows the extent of meeting the purposes of SCGVW. The purpose of SCGVW is to improve K-12 students' impression about the construction industry, arouse K-12 students' interest in construction and increase K-12 students' construction knowledge. In order to test purposiveness of SCGVW, we asked same question both before and after gaming. A five point scoring system was used (very poor=1, poor=2, average=3, good=4, and very good=5) in order to calculate impression about the construction. Compared to before gaming, impression about the construction industry is improved 0.24 point. After gaming, five students wanted to work in the construction industry for their career as against only two students did before gaming. Having them got 76 percent of the answer right after gaming compared to 65 percent before gaming, K-12 students also obtained construction knowledge through playing SCGVW. Consequentially, it is demonstrated that SCGVW satisfies the purposiveness. Questions about K-12 students' behavior and needs were performed after gaming. K-12 students responded that acting as a construction employee when role-playing with friends was most effective to understand construction and interesting. These results describe that group playing environments which arouse social interaction is effective way to educate K-12 in terms of motivation. Lastly, most of K-12 students wanted to know more about the process of constructing a building and the factors that are needed to construct a building. These learning contents of knowledge are needed to be covered in the future study.

Although the designed scenario meets the purpose of development and the results of applicability test are encouraging, SCGVW has a lot to be improved. First of all, it is needed to design scenario more realistically. SCGVW emphasized on managerial skill and interpersonal skill in order for K-12 students' learning of construction work. We focused on putting K-12 students in the center by enabling them to mediate different opinion with other people and control their learning. However, technological knowledge is one of important part of construction education as well. Visualized two-story building may have been insufficient for K-12 students to learn about technological knowledge in construction work. Through applicability test, it is identified that K-12 students also want to know about specific construction process. The level of detail of construction activities is required. The next research step is to develop a specific project-based scenario which K-12 students can experience similar situations in reality. SCGVW represents only the first step in development of construction educational tool. In terms of a larger K-12 students being able to take part in learning environment over internet than traditional classroom, SCGVW demonstrated on the possibilities of coming into wide learning. However, SCGVW has still limitations of applying technological component. In SCGVW, there are feedback using computer simulation and visual simulation, but it's incomplete. Technology application is an important part of developing SCGVW in terms that SCGVW is technology-based space which provides K-12 students with reinforcing the learning process. Further researches on application of technology are required.

5. CONCLUSIONS

Construction industry's images are negative despite of its significant contributions in economy of country. We examined construction education is the key to the solution for changing this poor images. In this context, this paper proposed SCGVW as a medium for capturing K-12 students' interest and improving image of construction industry. SCGVW targets K-12 students who are under the style game generation. We focused on educate CM, related to acquiring a set of management skills and interpersonal skills. Based on literature review, conceptual model is designed. Put simply, the concept is that avatars construct a building collaboratively in uncertain virtual construction site. We developed scenario and prototype of SCGVW. SCGVW is composed of computer simulation module, visual simulation module and virtual world module. SCGVW utilizes interactive and immersive functionalities of virtual world environments, and computer and visual simulation model that represent construction systems in the real world. The SCGVW implementation is demonstrated to improve K-12 students' construction image, obtain construction knowledge and arouse K-12 students' interest through collaborative role-playing. The contribution of this research is SCGVW serves to guide future development of educational tool for K-12 by demonstrating how scenarios have been developed and implemented. The next research step is to extend the level of detail of construction activities and the functionality of SCGVW.

REFERENCES

[1] Asakawa T. and Gilbert N., "Synthesizing experience: Lessons to be learned from internet-mediated simulation games" *Simulation & Gaming*, Vol. 34(1), pp.10-22, 2003.

[2] Bain C. and Newton C. "Art games: Pre-service art educators construct learning experiences for the elementary art classroom." Art Education, Vol. 56(5), pp. 33-40, 2003.

[3] Brown, A. and Palincsar, A., "Guided, cooperative learning and individual knowledge acquisition", *Knowledge, learning and instruction*, Lawrence Erlbaum Associates, pp. 307-336, 1989.

[4] Brown, J. and Duguid, P., "Organizing knowledge" *California Management Review*, Vol. 40, pp. 90-112, 1998.

[5] Bruner, J., *The process of education. Cambridge*, MA: Harvard University Press, 1960.
[6] Derry, S. J., A fish called peer learning: Searching for common themes, *Cognitive perspectives on peer learning,* Mahwah, NJ: Erlbaum, pp. 197-211, 1999.
[7] Fiori C.M., "What's wrong with working in construction? How image and diversity issues are affecting the shortage of skilled labor", *Construction Research Congress 2003*, pp. 1-8, 2003.
[8] Ginige, K. N., Amaratunga, R. D. G., and Haigh, R., "Improving construction industry image to enhance women representation in the industry workforce", *Procs 23rd Annual ARCOM Conference*, 3-5 September 2007, Belfast, UK, Association of Researchers in Construction Management, pp. 377-385, 2007.
[9] Harmon S.W., "A theoretical basis for learning in massive multiplayer virtual worlds." *Journal of Educational Technology Development and Exchange*, Vol. 1(1), pp. 29-40, 2008.
[10] Harris Research Centre, Report on survey of undergraduates and sixth formers, *King's Lynn: CITB*, 1989.
[11] Hayes, E., "*Find out who you really are: Adult learning in virtual worlds*", Paper presented at the Adult Education Research Conference (AERC), May 24-26, North Carolina State University, Raleigh, NC., 2002.
[12] Jamaludin, A. Chee, Y.S., and Ho C.M.L. "Fostering argumentative knowledge construction through enactive role play in Second Life." Computer & Education, Vol. 53, pp.317-329, 2009.
[13] Kiriemuir, J., *Video gaming, education and digital learning technologies*, D-Lib Magazine, Vol. 8, 2002.
[14] Koster, R., "Chapter 3: What games are. In A theory of fun for game design". *Scottsdale, AZ: Paraglyph Press*, pp. 34–47, 2005.
[15] Ku K. and Mahabaleshwarkar P.S., "Building interactive modeling for construction education in virtual worlds", *Journal of Information Technology in construction*, Vol. 16, pp. 189-208, 2011.
[16] McFarlane, A., Sparrowhawk, A., & Heald, Y., Report on the educational use of games, 2002. (http://www.teem.org.uk/publications/teem_gamesined_full.pdf).
[17] Miller, C. H., "Chapter 8: Blending entertainment with other goals. In Digital storytelling: A creator's guide to interactive entertainment", *Burlington, MA: Focal Press Elsevier*, pp. 159-182, 2005.
[18] Nederveen, S., "Collaborative design in Second Life," *Second International Conference World of Construction Project Management*, October 24-26, Delft, The Netherlands, 2007.
[19] Ng, W., Khor, E., and Lee, J., "Simulation Modeling and Management of Large Basement Construction project", *Journal of Computing in Civil Engineering*, ASCE, Reston, VA, Vol. 12 (2), pp. 101-110, 1998.
[20] Peña-Mora, F. and Park, M., "Dynamic Planning for Fast-Tracking Building Construction Projects", *Journal of Construction Engineering and Management*, ASCE, Reston, VA, Vol. 127 (6), pp.445-456, 2001.
[21] Prensky, M., *Digital game-based learning*, New York: McGraw-Hill, 2001.
[22] Rosenthal, S., *Bridging the cultures of engineers: Challenges in organizing for manufacturing product design*, Process. Newyork: McGraw-Hill, 1990.
[23] Selingo, J., "Powering up the pipeline schools hope their innovative K-12 programs will propel more students into college engineering courses-and careers", ASEE Prism, April, 2007.
[24] Sherif, A. and Mekkawi, H., "Excavation Game: Computer-Aided-Learning Tool for Teaching Construction Engineering Decision Making", *Journal of Professional Issues in Engineering Education and Practice*, Vol. 136(4), pp.188-196, 2010.
[25] Soller, A.L. "Supporting social interaction in an intelligent collaborative learning system", *International Journal of Artificial Intelligence in Education*, Vol. 12, pp. 40-62, 2001.
[26] Tenenbaum, G., Naidu, S., Jegede, O., and Austin, J. "Constructivist pedagogy in conventional on-campus and distance learning practice: An exploratory investigation." Learning and Instruction, Vol. 11, pp.87–111. 2001.
[27] Tews, R. R., "Chapter 9: Archetypes on acid: Video games and culture", The medium of the video game, Austin: University of Texas Press, pp. 169–182, 2001.
[28] Vygotsky, L.S., *Mind and Society: The development of higher psychological Process,* Harvard University Press, Cambridge, MA, 1978.
[29] Wilkins, B. and Barrett, J. "The virtual construction site: a web-based teaching/learning environment in construction technology", *Automation in Construction*, Vol. 10, pp.169-179, 2000.
[30] Wlodkowski, R. J., *Motivation and teaching: A practical guide,* Washington, D.C.: National Education Association, 1986.
[31] Wolf, M. J. P. (2001). *"Chapter 6: Genre and the video game"*, The medium of the video game, Austin: University of Texas Press, pp. 113–134, 2001.