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LEARNING CONSTRUCTION PROJECT MANAGEMENT IN THE VIRTUAL WORLD: LEVERAGING ON SECOND LIFE

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SUMMARY: The paper presents potential utilization of Second Life© (SL) in enhancing learning/training construction project management. The virtual environment supports the learning process by enabling learner to visualize the construction projects in 3D. Furthermore, SL provides an excellent platform for learners to interact with their peers and mentors in this virtual environment for exploring the learning activities collectively. The learners, as a group, learn more effectively by using virtual environment where they can get involve in life-cycle of a building project i.e., from conceptual design to completion stage dealing with major issues like resources, cost, quality and time. Project-based learning is an appropriate paradigm for addressing construction project management problems. The dynamic nature of SL provides an excellent platform for learner groups to interact and go through various aspects of the building project collaboratively. The virtual environment of SL supports the learning process by quick and easy visualization the construction projects. Furthermore, SL provides virtual environment for learners where they can interact with their peers and mentors for exploring the learning activities collectively. SL is a truly global venue where participants from across the world can be invited to work collaboratively and to provide feedback on construction projects. This interactive approach toward construction projects helps in sharing experiences and improving quality of understanding of the real life issues in construction project management in virtual environment, eventually eliminating risks of making costly mistakes on site. This paper highlights the benefits and challenges of the application of SL for learning construction project management. Findings of this study were validated through active feedback collected from a group of learners using SL in an academic environment. Furthermore, this study also contributed to knowledge as the findings of this research can be used by future researchers to carry out studies on the similar application of virtual reality for fostering strong learner involvement in the learning process. The study would be beneficial for building professionals involved in the academia in general.

KEYWORDS**:** Virtual reality, construction, project management, second life, visualization.

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1. INTRODUCTION

Information technology has become strongly established as a supporting tool for many professional tasks in recent years. Virtual reality (VR) simulations provide powerful teaching tools that can help learners digest complex concepts and retain them long after the session is ended (Arain and Burkle, 2009). VR simulation is a natural concept for inclusion in construction engineering education. It eliminates the risks and costs associated with the real world whilst enabling people to gain many of the professional experiences. Virtual environments have been a focus of research interest for a number of years because of their potential applications in training, education, visualization, design and entertainment (Park and Wakefield, 2003). An important aspect of virtual environment systems is realistic simulation of a 3D environment. VR is an emerging technology to simulate the real world on the computer and is being applied to many fields of industries and academia. The uses of VR assist in learning beyond physical constraints. VR presents an interactive environment that enhances the learning ability especially on a complex project.

During the recent past years, virtual worlds have become an important part of teaching and training, transforming the way people work and learn. Education has been influenced by the changes in the area of Information and Communication Technologies (Conklin, 2007). VR is an emerging technology to simulate the real world on the computer and is being applied to many fields. Virtual worlds have also started to transform the way students have access to content, entertainment, and knowledge, making content portable and therefore, transforming the physical limits of the classroom (Arain and Burkle, 2009).

Both formal and informal education happens in Second Life (SL). Formal education refers to classes, training, instruction, and simulations. Informal education includes immersive museum exhibits, informal chatting on academic topics, role-playing, etc (Kervin and Vardy, 2006). Furthermore, learning takes place in SL using all the possible forms of knowledge sharing and acquisition: network and collaboration, in an immersive experience and a participatory culture (Conklin, 2007). At the time of writing, 122 educational institutions have a virtual campus in SL and these spaces become part of the education community around the world. However, using SL to teach and learn is still a new experience and one that needs further testing and research.

Innovative educators around the world are exploring how virtual worlds can serve as powerful educational tools in instructors' and students' approach to teaching and learning. SL use in higher education institutions is relatively new and there are already some good examples (best practices) of universities, colleges and polytechnics that have made use of the technology in a very efficient way. In an academic setting, SL has become an accepted virtual platform and a channel of communication between instructors and students, between students themselves, and among faculty, as they have discovered the potential of creating virtual environments of lectures and other course materials. And because SL use is not restricted to the classroom limits, its use in a higher education institution context can take the learning process beyond the boundaries of the classroom and can offer anytime/anywhere opportunities for teaching and learning (Arain and Burkle, 2009). However, the novelty of the use of virtual worlds for education brings with it the challenge of developing pedagogical understandings around the relationship between the use of synthetic experiences and the educational context within contemporary society. There are still many questions to be answered in relation to what are the 'new' benefits that instructors and students will receive after using SL for learning or how can we usefully expand the learning opportunities so that SL can become a valuable learning tool.

Construction projects are complex because they involve many human and non-human factors and variables. It is difficult to teach much of this in a traditional manner (Arain *et al.*, 2004). It is also expensive and potentially dangerous to allow a person to learn the management skills on construction site. Simulation is therefore a perfect fit for training in this area. VR simulations, if utilized in teaching and analyzing construction management processes, can save costs while maintaining or even improving the performance and quality of learning process (Arain and Burkle, 2009). VR simulation of construction and management processes is highly needed due to the escalating complexity of building projects.

The paper presents potential utilization of SL in enhancing learning/training construction project management. The virtual environment supports the learning process by enabling learners to visualize the construction projects in 3D. Furthermore, SL provides an excellent platform for learners to interact with their peers and mentors in this virtual environment for exploring the learning activities collectively. This paper highlights the benefits and challenges of application of SL for learning construction project management. Findings of this study were validated through active feedback collected from a group of learners using SL in an academic environment.

2. BACKGROUND

Construction Project Management is of immense importance in boosting the construction industry growth of any country. The rapid trend of technological changes have made difficult for construction professionals to survive without adopting technological expertise in the competitive world. It is commonly accepted that the construction industry has for many years been criticized for not developing consistent projects that are on time, within budget and with high quality standard (Arain and Low, 2005). Generally, failure to deliver successful projects has been considered in relation to schism between design and construction, lack of integration, lack of effective communication, uncertainty, changing environment, and increasing project complexity. These causes, together with common project changes caused by design discrepancies, and errors in designs, have led construction professionals to rely on information technology for successful completion of project without unwarranted mistakes (Mokhtar *et al.*, 2000).

The uses of VR not only make us transverse the time and space to feel a planning project but also strongly engage users to have a quick understanding on any complex project. It can present the real world including objects and phenomena in a compact environment in three dimensional formats (Arain and Burkle, 2009). VR contributes to the learners' participation into the learning process and the invention of ways, which facilitate the active construction of their knowledge structure, as well as the understanding of the process.

2.1 Construction project management education

Construction project management is the study of how the principles of scientific management are applied to construction projects (Kramer, 2005). It also covers maintenance of existing buildings and management of construction companies. Various management tools and theories are used to solve problems relating to the planning and control of construction projects. The core establishes the professional basis for successful operations in development projects as well as a strong basis for advanced studies in related areas (Arain, 2007a).

Construction-related programs face a significant challenge of providing students with knowledge that works in industry (Arain and Low, 2007). It is, therefore, not surprising that construction programs are allocating more time in their curricula to provide students with such learning opportunities (Park and Wakefield, 2003). As a way of meeting this need, a number of technological and pedagogical innovations were designed, tested, and implemented successfully into construction programs. These innovations include internships, multimedia-based learning, service-learning projects, simulation, and games (Park *et al.*, 2003).

Many researches suggested that the more complex the real life situation, the more suitable virtual environment is to help people understand it and learn to manage it but the more difficult it is to produce a model of it which behaves realistically (Gribble *et al.*, 2006). The management of a construction project is a typical area which is complex with many interrelated aspects (Arain and Low, 2006a; Arain, 2007b). It is difficult to teach much of this in a traditional manner. It is also expensive and potentially dangerous to allow a person to learn the management skills on-the-job (Hegazy, 2006). It is therefore an area in which virtual simulation might naturally be used.

Constructivist curricula often emphasize group activities designed in part to facilitate the acquisition of collaborative skills that are typically required within contemporary work environments (Park and Meier, 2007). Such group activities may offer students of varying ages and ability levels, and having different interests and prior experience, the opportunity to teach each other - a mode of interaction that has been found to offer significant benefits to all parties. Park and Meier (2007) suggested that the curriculum in construction management programs should include instruction in constraint-based simulation tools. This instruction must specifically address issues that relate to construction schedule verification, generation and decision support for alternative schedules, better coordination and communications among project team members, effective temporary structure design, and improved work-site safety.

To realize the benefits the constructivist learning paradigm offers, it is essential to provide students with an interactive inquiry-based learning environment where they are required to take an active role in the learning process and expected to expand and evaluate their own thinking (Park and Meier, 2007). In the domain of construction project management, the virtual construction simulation technology is in general equipped with the features of constructivism. The existing virtual construction technology, however, does not allow students to realize the outcomes of their own knowledge building process because it is heavily based on graphical representations, not incorporated with the business process and communication information, the importance of which should be kept at the maximum level in the construction management curriculum development to provide realism in the learning environment (Park and Meier, 2007).

Virtual construction environment becomes a true tool for learning and understanding the management process associated with the real construction projects (Park and Meier, 2007). This innovative environment will change the way construction education is done based on the solid pedagogical paradigm, and how the construction business aspect is implanted into the existing CM curricula (Khan, 2001). The web-based project collaboration component specifically enhances other critical aspects in construction education such as facilitating synergistic collaboration between discipline-different, but yet related, all construction technology academic programs, such as construction management, civil engineering, and architecture programs (Ahmed *et al.*, 2007; Park and Meier, 2007).

2.2 Significance of virtual reality in construction project management

E-learning has occurred in the academic world in different forms since the early 1990s (Ahmed *et al.*, 2007). Its use varies from interactive multimedia tools and simulation environments to static resources within learning management systems. E-learning tools and environments are no longer criticized for their lack of use in higher education in general and within the construction domain in particular (Ahmed *et al.*, 2007). VR is an emerging technology to simulate the real world on the computer and is being applied to many fields (Pierce *et al.*, 1995; Park *et al.*, 2003). The application of VR can assist in understanding the complex nature of the project and exploring suitable options in an economic way (Savioja *et al.*, 2003). It can present the real world including objects and phenomena in a compact environment in 3D format and make users transport time and space to feel a virtual world.

VR offers a natural medium for users, providing a three-dimensional view that can be manipulated in real time and used collaboratively to explore and analyze design options and simulations of the construction process (Bouchlaghem *et al.*, 2005). It is only recently that VR has started to be used in construction projects and there has been little empirical investigation of VR technologies by companies in the construction sector (Woksepp and Olofsson, 2006). For example, the appropriate use of VR models in the different phases of a construction project is still not clear (Westerdahl *et al.*, 2006).

VR can be viewed as an innovative approach for delivering a well designed, learner-centered, interactive, and facilitated learning environment to anyone, anywhere, anytime by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for an open, flexible, and distributed learning environment (Khan, 2001).

The students, as a group, learn more effectively by using virtual environment where they can get involve in life-cycle of a building project i.e., from conceptual design to completion stage dealing with major issues like resources, cost, quality and time. Project-based learning is an appropriate paradigm for addressing construction project management problems. Project-based service learning projects provide a hands-on opportunity for students to address real-world problems in a multidisciplinary, collaborative environment (Mason and Moutahir, 2006). The dynamic nature of the virtual environment provides excellent platform for student groups to interact and go through various aspects of the building project collaboratively. The virtual environment supports the learning process by quick and easy visualization the construction projects. Furthermore, in a virtual environment learners can interact with their peers and mentors for exploring the learning activities collectively. Virtual world is a truly global venue where participants from across the world can be invited to work collaboratively and to provide feedback on construction projects (Arain and Burkle, 2009). This interactive approach toward construction projects helps in sharing experiences and improving quality of understanding of the real life issues in construction project management in virtual environment, eventually eliminating risks of making costly mistakes on site.

Virtual simulation environments with a web-based collaboration tool as a way of simulating construction-related processes would assist in effective management of construction projects (Park and Meier, 2007). This new environment requires that students exchange project-specific information with others to plan required resources, to receive and apply the right information into a non-constraint virtual construction environment. It is very challenging to develop knowledge based virtual simulation learning environment where graphical construction operations are constrained realistically according to construction process information (Park *et al.*, 2003). Virtual simulation environment provides students an opportunity to see how different project stakeholders impact their performance and how information and resource-constraints play a critical role in the success of the project (Park and Meier, 2007).

In the domain of construction project management, it is essential to provide students with an interactive learning environment where they are required to take an active role in the learning process and expected to expand and evaluate their own thinking (Arain and Low, 2007). The virtual construction simulation technology is an excellent example of the features of constructivism available in the virtual environment for the learners. Overall, dynamic virtual reality may assist construction project management students in perceiving the complex projects, making project design more reasonable, and low cost, understanding the issues of site planning and management, equipment management, solving project related issues based on informed and quick analyses, communicating and coordinating effectively among local and global participants. Furthermore, construction project management students capitalizing on the features of constructivism in the virtual environment can also experiment with numerous construction materials, equipment and forms of spaces to achieve the best possible solution for construction projects.

2.3. The virtual learner

The significant changes that today's students bring with them when they start their post-secondary education creates an urgent call to understanding the different ways they learn and therefore, to change the way institutions educate them. But it is time not only to radically change the way teaching takes place, but also, to redesign curriculum, graduation processes, evaluation methods, infrastructure needs, etc. (Harvey, 2010).

Web 2.0 technologies are here to test educational institutions making such a transformation (Anderson, 2007; Evans and Nation, 2000; Mason, 1998). Moving content from a static to a dynamic perspective, changing the lecture-centered relation of classroom teaching to a more student-centered one, breaking the old image of the instructor as the only knowledge holder, promoting collaborative approaches to teaching, etc. are some of the challenges they have started to face.

As a result of the omnipresence of technology, today's students think and process information differently than their predecessors (Prensky 2001; Bonk, 2009; Burkle, 2010). Even more so, their entire beliefs and values are different from those in their previous generation and these differences usually go further and deeper that most educators realize. These are some of the reasons why today's students have received the title of being digital natives (Prensky, 2001). In coining this term, Prensky is making the analogy of natives to a homeland and in this case he refers to the digital land, or those who have always known the internet. Others have called this new generation of students the Net Gen where net refers to networking or internet use. Whether digital natives or net-geners, this generation was born when the computer was an important part of the dynamics of a home, where the Internet had become an integral part of daily activities.

With the arrival of the digital natives or NetGeners to higher education institutions, the use of virtual environments to access learning content has started to be seen as an engaging way for them for the provision of content and knowledge exchange. The introduction of VR into the learning experience is expected to foster active learning by engaging students in the process and facilitating their interaction with learning and content. Used effectively, individual technologies have the potential to change the learning dynamic and foster new pedagogical approaches, enabling the instructor to promote collaborative, independent learning (Callaghan *et al.*, 2006; Burkle, 2010).

3. LEARNING CONSTRUCTION PROJECT MANAGEMENT IN SECOND LIFE

The construction project management discipline is complicated by its nature, as it consists of a number of domains that are closely interlinked (Kahkonen, 2003). The knowledge of one domain requires some knowledge of another, many human and non human factors and variables also add up to the complexity of management processes of construction projects (Arain and Low, 2006b). This requires curriculum developers to rely on new technology to introduce and help training that can address to the project complexity. Construction-related programs face a significant challenge of providing students with knowledge that works in industry. It is, therefore, not surprising that construction management programs are now relying on new technologies particularly VR to provide students with such learning opportunities.

VR today tends to be focused primarily on enterprise and entertainment which do not usually contribute towards educational goals (Woksepp and Olofsson, 2006). As a response to this issue, an educational world i.e., SL has been developed, in an attempt to encourage a wide use of these virtual environments in traditional subject areas (Rymaszewski *et al.*, 2006). The virtual environment strongly encourages learners' engagement and enhances learning process. Building students develop 2D drawings and specifications, and based on the given information they plan and manage the project for its construction phase. VR contributes to the student's participation into the learning process and the invention of ways, which facilitate the active construction of his knowledge structure, as well as the understanding of this process (Dawood *et al.*, 2005). Recently, an increasing number of educators have access to SL. Through the VR, teachers and students can have a direct access to 3D learning environments on the Internet (Messner *et al.*, 2006). SL gives teachers the opportunity to enhance their students' knowledge; while simulated spaces can help students visualize information in new and realistic ways, give abstract concepts a realistic flavor and encourage cross-cultural, global communities (Kahkonen, 2003; Rymaszewski *et al.*, 2006).

Students of construction program get excellent opportunities in SL to explore the construction processes and building projects in a virtual environment. SL would assist in interactive learning as compared to traditional learning from theoretical approaches. The implementation of SL can offer to both students and educators alike, quick access to visualization of building spaces and construction planning. SL offers a natural medium for users, providing a three-dimensional view that can be manipulated in real time and used collaboratively to explore and analyze design options and simulations of the construction process. Through the 3D visualization of construction processes and methodologies, the learners may also participate in research or problem-solving activities which help acquire a wider and broader perspective of construction (Bouchlaghem *et al.*, 2005).

SL ideally blends with the learning environment that encourages hands-on learning (Rymaszewski *et al.*, 2006). Experiential education is a core component of construction project management curricula. In a project based learning environment, students work in teams to solve real-world problems. As opposed to traditional, text-oriented problem or system description in most of the textbooks, a virtual world has the advantage that most of the system states, for example, assembly line station, production floor, and inventory storage etc. are available and explored based on real life principles in the virtual world (Mason and Moutahir, 2006). SL will assist in illustrating actual problems found in industry that are related to the construction project. Students experience various stages of construction projects and how it changes over time. Also, SL encourages exploration in creating variants of existing worlds and making novel worlds of their own. Another important intelligent feature of SL is the ability to apply natural characteristics to materials and components of a building project. This feature enables students to explore and analyze impact of lighting on the exterior and interior of building and how it changes with various arrangements. Students may explore impact of weight, size, and form of construction materials and components in the virtual environment.

SL environment not only presents a quick understanding to the structural inner parts but also presents a mechanical state under external forces and even the possible damage part (Rymaszewski *et al.*, 2006). Learners can benefit from SL environment in getting a visual concept that only be created by imagination when using 2D drawing. The three dimensional visualization assists in analyzing and understanding the complexities of a construction project.

3.1 Visualizing construction project in 3D

Project-based learning is an appropriate paradigm for addressing construction project management problems. The dynamic nature of SL provides excellent platform for learner groups to interact and go through various aspects of the building project collaboratively. The virtual environment of SL supports the learning process by quick and easy visualization the construction projects. SL provides an excellent venue for construction project managers to visualize the project in 3D. Project drawings can be imported to SL environment as shown in Figure 1. Project drawings provide the base for developing construction project, identifying materials and other resources required. The 3D visualization of building project would assist in identifying potential technical and management issues with the project at an early stage. Project team would be able to perceive the physical form of the project that would enhance their understanding of the physical constraints and issues associated with the project.

FIG. 1: SLAIT Robotics Factory visualization in Second Life

3.2 Project teamwork in SL

Project teams are one of the most important resources for construction project management. Professionals have to interact among themselves to coordinate the project progress for effective management of construction projects (Arain *et al.*, 2004). SL provides virtual environment for learners where they can interact with their peers and mentors for exploring the learning activities collectively. SL is a truly global venue where participants from across the world can be invited to work collaboratively and to provide feedback on construction projects as shown in Figure 2. SL provides options for the project management team to access and interact at the virtual project site as shown in Figure 3. As mentioned, the project team members can participate in the project in SL environment from all around the world. This interactive approach toward construction projects helps in sharing experiences and improving quality of understanding of the real life issues in construction project management in virtual environment, eventually eliminating risks of making costly mistakes on site.

FIG. 2: Project Participants Gathering for Project Briefing on Virtual Manufacturing Band Project in SL

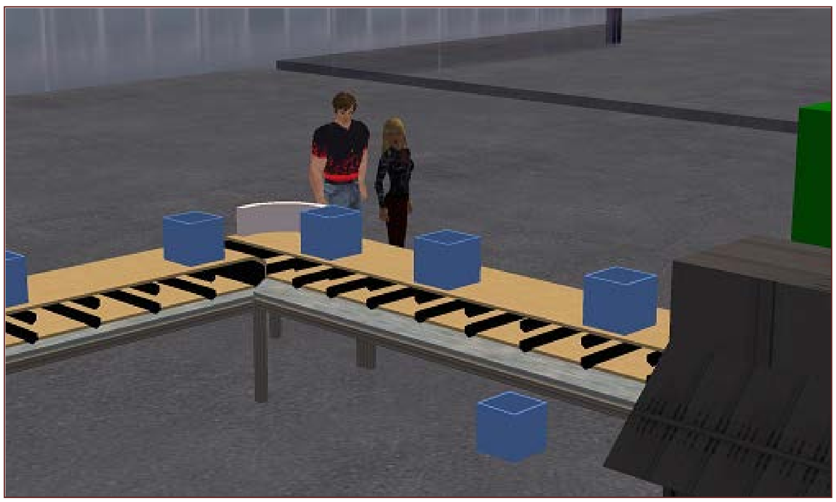

FIG. 3: Project Team Interacting on a Virtual Manufacturing Band Project in SL

3.3 Resource management in SL

In SL environment, project management team can identify the materials, equipment, and technical resource requirement. It is suggested that the project team develop a comprehensive list of resources required. The dynamic nature of SL would allow learners to share materials and equipment among different projects as shown in Figure 4. Project team can develop an effective site management plan by utilizing the real site contours and other physical constraints associated with the project site. The real life simulations provided in SL would assist in planning and managing materials and equipment for building projects. As shown in Figure 5, resources required for the mecatronics lab were identified that enhance understanding of physical constraints. It also provides an excellent opportunity for project team to experiment with various spatial arrangements and sequences of resource supply and installation to identify the best possible resource management for the project.

FIG. 4: Equipment and Tracks for Project in SL

FIG. 5: Mecatronics Lab in SL

As mentioned above, the project-based learning provides a hands-on opportunity for students to address real-world problems in a multidisciplinary and collaborative environment.

3.4 Project optimization in SL

SL provides an excellent platform for achieving project optimization by analyzing various aspects of the projects. An intelligent feature of SL is the ability to apply natural characteristics to materials and components of a building project. This feature enables students to explore and analyze impact of various materials on the exterior and also the indoor quality of the projects. Students may explore impact of weight, size, and form of construction materials and components in the virtual environment. SL environment can also be used to create real life site situation to explore constraints in site management as shown in Figure 6. This would assist in effective site planning that include storage of materials, equipment placement, movement of project machinery, and also site safety analysis.

FIG. 6: Project Manager Visualizing the Project Perimeters for Site Planning of Robotic Lab in SL

As mentioned earlier, SL environment not only provides a quick understanding to the structural inner parts but also gives a mechanical state under external forces and even the possible damage part. Learners can benefit from SL environment in getting a visual concept that only be created by imagination when using 2D drawing. The 3D visualization assists in analyzing and understanding the complexities of a construction project as shown in Figure 7. As an interactive virtual platform, SL is very dynamic and user-friendly. Project team members (virtually from across the globe) can interact among themselves on the project site and explore the best possible solutions to any constraints that hinder effective implementation of the project.

FIG. 7: Project Manager Visualizing the Complexities of a Robotic Lab in SL

4. FEEDBACK ON POTENTIAL UTILIZATION OF SECOND LIFE

There is an immense increase in utilization of SL by an increasing number of educators in recent years. Through SL, trainers and learners can have an easy access to three dimensional learning environments on the Internet. SL provides educators the opportunity to enhance their students' knowledge by capitalizing on the simulated spaces that can help students visualize information in new and realistic ways. It assists in understanding the abstract concepts in a realistic flavor and encourages cross-cultural, global interaction in professional communities.

In June 2008, a group of innovative instructors of the Robotics and Multimedia Programs at Southern Alberta Institute of Technology (SAIT) decided to explore the possibilities of using SL for enhancing the learning experience of their students. A team was put together to design a working plan and research needed to be done in order to build a proper learning environment in SL. The main objectives of the project *SAIT in Second Life* (SLAIT) were to enhance the virtual learning environment; to accommodate a variety of learning styles that will allow students to preview and review virtual demonstrations upon desire and demand; to enhance the use of SL in the educational process; to allow the instructors to test a virtual environment (virtual sandbox) for teaching 'hands on' skills; to allow learners to be more independent in controlling the pace and timing of their learning; and to reinforce the student-centred nature of learning.

The group decided to purchase two islands in SL, to start building learning environments. Two groups of students in two different programs were targeted 1) the Robotics students in the School of Manufacturing and Automation, and 2) the Multimedia students in the School of Information Technologies.

It is revealed in the interviews with the instructors that SL has brought a number of benefits to teaching and learning processes and the virtual simulation is going to be huge in the next 50 years. In SL, it is possible to simulate some parts of real life in quick and efficient ways particularly the interaction between people and representations of physical objects such as structures, furniture, equipment, vehicles, etc. The group suggests that SL represents a number of amazing possibilities ranging from the use of group discussions with learners around the world to the possibility of exploring equipment and facilities simulations. It was also highlighted that finding a balance between time consumed (in making objects and scripting) and results obtained was one of the challenges.

In order to collect SAIT students' feedback on the use of SL for learning, an online survey was applied to students using the 'virtual classroom' in SL, and a focus group took place with registered students in the Robotics Program. Questions in the survey were focused on using SL to retrieve academic information, the appropriateness of using SL to promote student engagement and students' interest in using virtual environments for learning.

It is interesting to note that 30% of the students were using SL for the first time. 57.9% of the surveyed population agreed that SL was a favorable place to interact with classmates, friends and faculty, while 68.4% agreed that SL was a good channel for education and training. Regarding the use of the SL island to obtain academic information, 46.7% of the students found the island to be instructive while 84.6% considered visiting SL island help them in learning construction layouts and challenges.

Findings from the focus group reflect students' interest in using virtual environments for learning. All of them expressed the learning process in SL as an engaging and fun experience. A challenge for developers of SLAIT is to build an island that offers more interaction for students as some of them stated that they found the information a bit impersonal and distractive. Finally, it is important to state that students suggested that SL should be always complementary to a real face-to-face learning experience, where they could discuss projects in real scenarios.

5. CONCLUSION

Construction projects are complex because they involve many human and non-human factors and variables. It is difficult to teach much of this in a traditional manner. It is also expensive and potentially dangerous to allow a person to learn the management skills on site. It is therefore an area in which simulation might naturally be used. SL is an excellent tool for teaching and analyzing construction project management processes. Construction students can learn and experiment site planning and management in the virtual environment by arranging various resources i.e., equipment, manpower, materials etc. required at site for the construction project. This would assist the students in planning effectively and most cost efficiently. Utilization of SL in teaching construction project management courses can save costs while maintaining or even improving the performance and quality of learning process. Construction and management processes in virtual environment created by SL are highly needed due to the escalating complexity of building projects.

Overall, SL's dynamic environment assist construction students in perceiving the complex projects, making project design more reasonable, and low cost, understanding the issues of site planning and management, equipment management, solving project related issues based on informed and quick analyses, communicating and coordinating effectively among local and global participants. Furthermore, SL also provides an excellent platform for learners to perform experiment with numerous construction materials, equipment and forms of spaces to achieve the best possible solution for construction projects.

The article suggested the potential utilization of SL in teaching and learning design processes, construction engineering and management of building projects. The learners would learn more effectively by using SL simulations and games that involve them in life-cycle of a building project i.e., from conceptual design to completion stage dealing with major issues like resources, cost, quality and time. Based on faculty members and students' feedback, it is endorsed that SL is a fun and interactive learning environment. It is recommended that SL simulations or games should be developed for teaching design and construction processes and project management of building projects. This article sets the foundation for future research focusing on developing VR simulations and games for teaching design and construction processes of a building project. The findings of this study would be valuable for all academicians and professionals involved in developing academic and professional programs in the area of architecture, construction project management and civil engineering in general.

The existing SL environment, however, does not allow students to explore complex details of materials and components of the construction projects. The spaces and products can be created by using only basic forms, with an opportunity to import graphics to create a more natural finish of materials and components.

SL as one of the virtual reality tools in construction project management can be used by future researchers to carry out studies on the similar application of virtual reality for fostering strong learner involvement in the learning process. The suggested utilization of SL in learning construction project management would be helpful for professionals to take proactive measures for successful project management of the building projects. The study would be beneficial for building professionals involved in the academia in general.

6. FUTURE WORK

This study presented the potential utilization of SL in teaching and learning management of building projects. Eventually, the main focus of future work could be the development of construction project management virtual projects and SL simulations or games for teaching design and construction processes and project management of building projects. Further research is recommended to incorporate more intricate details of construction projects in SL environment. This would provide the professionals with requisite knowledge to make more informed decisions and to take proactive measures for successful management of building projects.

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