Integrated Intelligent Research (IIR)

International Journal of Computing Algorithm
Volume: 05 Issue: 01 June 2016, Page No. 23- 28
ISSN: 2278-2397

A Framework for Desktop Virtual Reality Application for Education

J. Frank Reuben Jebaraj [1], E. Kirubakaran [2]
[1]Asst. Prof. in MCA / The American College, Madurai, India
[2]AGM / SSTP Systems/ Bharat Heavy Electricals Limited, Tiruchirappalli, India
Email: j_frankreuben@yahoo.com, e_kiru@yahoo.com

Abstract: Contemporary custom in education encourages students to gain exposure in the real world through student visits (field visits) to sites in count to conventional textbooks and lectures. This disclosure helps students to experience real world situations and integrate this experience into knowledge learned in class. This is important to students in various disciplines such as engineering, architecture and transportation. Students, however, have limited on-site access due to issues related to safety concerns, cost and effort. In an attempt to address such issues, Virtual Reality (VR) applications have been developed and implemented. With the growth in the number of VR applications, there is currently a lack of information about the design issues of VR applications from the standpoint of integrating different types of information associated with the real world. This paper aims to bridge this gap by evaluating VR applications with respect to these issues and highlights the lessons learned from the appropriate evaluations. The results demonstrate that VR application, which links different sources of information (as developed in this paper), promotes better learning than conventional printed materials and that students professed it positively as a precious complement to a physical field visit. The design recommendations for the development of similar VR learning applications are further discussed in this paper.

Keywords: Virtual Reality, virtual environment, practical knowledge, navigation, integrated information.

I. INTRODUCTION

In count to stereo typed textbooks and lectures, contemporary training in education encourages learners to gain exposure in the real world through field visits to sites such as process facilities for engineering students (e.g., McLoughlin, 2004), forests for forestry students (e.g., Morrell, 2003) and islands for landscape architecture students (e.g.,Egoz, 1999). This exposure to, and familiarity with, real world scenarios can be related to material learned in class room system. The exposure also enhances students' understanding of processes in the real world (Michie, 1998) and helps them to better remember processes that occurred during the field visits (Falk & Dierking, 1997). Understanding a process may comprise of the establishment of an educational institution or processing tea from tea leaves. Integrating classroom content with real world scenarios is important to students in various disciplines such as: *Engineering:* Students gain insights into real-time processes occurring in the real world. *Architecture:* Looking at designs of different buildings helps students gain insight into their scale. While exposure to the real world is important, learners have inadequate opportunities for this. Gaining on-site access can be difficult because of safety concerns (Abe et al., 2005; Klemm & Tuthill, 2003), weather (Lesley & Michael, 2005), time constraints (Abe et al., 2005), and cost and effort (Lesley & Michael, 2005; Lewis, 2008). Even if right of entry is likely, often it is a restricted, one-off visit that does not allow doing a tour on the site at the students' own pace. For that reason, learners may not be able to achieve adequate insight, which may make it hard for them to understand the concepts learned in class and to apply that learning to real-world scenarios. In addition to this, students with impaired mobility (e.g., wheelchair bound, hearing impaired) may find it difficult to participate in a site visit, although they may have the opportunity to attend one. In an attempt to address such issues, Virtual Reality (VR) applications have to be developed and implemented. VR applications create opportunities to 'bring the environment to the users' through interactive 3D environments to enhance the learning experience (Ausburn & Ausburn, 2004)[3]. However, with the growth of VR applications, there is currently a lack of information about the design issues of VR applications from the perspective of integrating different types of information related to the real world.

II. LITERATURE REVIEW

Virtual Reality (VR) is defined as "the combination of systems comprising computer processing (PC-based or higher), a building platform for creating three-dimensional environments, and peripherals such as visual display and interaction devices that are used to create and maintain virtual environments"; where a virtual environment (VE) is a three dimensional environment that allows users to interact with the objects within the environment in real time (Cobb & Fraser, 2005). Therefore VR provides an interactive, three-dimensional environment where users can manipulate and explore the environment (Sherman & Craig, 2003)[11]. The degree of VR varies from non-immersive to immersive, based on the level of the immersion provided (Vince, 2004). Immersive VR usually includes apparatus such as a Head Mounted Display (HMD), data gloves or Cave Automatic Virtual Environment (CAVE) that increases the user's sense of immersion in the VE. Non-immersive VR, on the other hand, runs on a standard desktop computer. Although this results in a decreased sense of immersion, no significant differences are evident in the learning outcomes between the immersive and non-immersive VR (Moreno & Mayer, 2002). The ability to use non-immersive VR on a standard desktop computer, without any additional apparatus, makes it a cheaper and more flexible option than immersive VR, and therefore makes it an adequate tool for training and education.

VR applications were initially developed and implemented in the military and the aviation industries for simulation training. However, as the technology became more robust and

International Journal of Computing Algorithm
Volume: 05 Issue: 01 June 2016, Page No. 23- 28
ISSN: 2278-2397

accessible, applications have been developed for other purposes such as education and training. In education, VR applications have been used to showcase physical sites (e.g., manufacturing plants (Cameron, Crosthwaite, Donaldson, Samsudi, & Fry, 2005), geological sites (Stumpf et al., 2008), forestry (Abe et al., 2005)), which are becoming difficult to access for reasons such as safety, cost and confidentiality. These applications will help students to be exposed to the materials learned in the class, which is useful to enhance their understanding.

VR applications have been widely used in various education disciplines such as engineering (Cameron et al., 2005), forestry (Abe et al., 2005), astronomy (Chih Hung, Jie Chi, Shen, & Ming Chang, 2007)[9], geology (Lewis, 2008) and audiology (Duenser, Heitz, & Moran, 2010). There are different types of VR application such as simulation-based applications, virtual characters and applications representing a physical environment. Simulation-based applications refer to applications that allow users to perform lab work, experiments or simulation activities. VR applications with virtual characters refer to visual representations of a character (e.g., humans) that are able to speak, move and interact with the users. An example of this application is a virtual patient used for training audiology students, where students can perform assessments of the virtual patient and it would provide responses related to the assessments. A VR application representing a physical environment involves the inclusion of panoramas or computer graphical representations (CG). This is intended to expose students to actual processes or scenarios that occur in a physical environment that would be difficult to access for various reasons such as safety concerns, weather and time constraints. Using a CG format to display the VE may result in limited visual details (Ruddle, Payne, & Jones, 1997). Additional VR applications have been developed using panoramas of realistic photos. Panorama based applications are easier to develop than using CG format because they involve taking a series of pictures (Chang, Lin, & Hsiao, 2009)[9] compared to CG format, which requires more development and modelling effort. Since this paper focuses on the use of a VR application with panoramas, as an alternative to exposing users to a physical environment (e.g., a field visit), the literature review focuses on applications using panoramas.

Design of Educational VR Applications

One of the challenges in developing educational software is to ensure that the applications are easy to use and simultaneously enhance learning. A well-documented instructional design principle for educational software is the theory of multimedia learning (Mayer, 1997, 2003, 2008), which states that learning takes place better when explanations are presented using a combination of both words and pictures instead of either words or pictures only. Words can either be spoken (e.g., narration) or printed (e.g., text). The theory of multimedia learning was developed based on the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2003), which demonstrates how learners learn from information presented in both words and pictures. This theory is based on three assumptions: 1.Dual-channel assumption: (Learners use two separate channels for processing audio and visual information representation). 2. Limited capacity assumption: (Only limited information can be processed in one channel at the same time). 3. Active learning:(Learning occurs when the learner is engaged in the cognitive processes of multimedia learning, which are selecting, organising and integrating words and images). Learning has higher effects in learners with low prior knowledge rather than high prior knowledge; and high spatial learners rather than low spatial learners. The overall cognitive process is not linear and learners may move from one process to another in any way. The theory suggests that learners have limited capability to process channels of both words and pictures. Therefore this suggests that by simply adding both words and pictures into a multimedia application do not help learning. The combination of words and pictures needs to be presented in a manner where it enhances learning without causing cognitive overload. A common feature of most of the reviewed VR applications, regardless of whether they are used as a learning resource or as a VFV, is the use of multiple pages to display linked information.

III. VR APPLICATION

In recent decades, research related to using VR application as a medium to relate classroom learning to a virtual environment (e.g., virtual field visit, educational software) has been conducted. On the contrary, applications developed for classroom learning with the inclusion of virtual environments contain various types of information to support students with their learning. The stimulus for the research related to this is therefore novel.

In modern decades, there has been a breakthrough in the development of VR applications in educational realm. Early developments focussed only on the inclusion of visual presentations with little additional information. With the growth of technology, current applications can make use of different information formats (e.g., 3D models, animations, videos and diagrams), including information that is not available in the real world such as looking inside a working machine (Bell & Fogler, 2004; Cameron et al., 2008; Norton et al., 2008)[5]. Combinations of information in different formats provide students with greater insights into real-world scenarios (Ausburn & Ausburn, 2004)[3].

The simplicity of developing VR applications, alongside the ability to include various types of information, demonstrates the advantages of VR applications with respect to conventional learning resources such as paper-based learning materials (e.g., textbooks, lecture notes), where these materials have restrictions in terms of displaying interactive and integrated information. The current state of the paper demonstrates that most VR applications use different locations (not within the same screen) to display information. An issue when using different locations (not within the same screen) to display information (particularly in word and picture formats) is the lack of integration between information, which may cause the students to have limited understanding compared with both words (e.g., in printed text or narration form) and pictures (e.g., illustrations or animation) being presented together (Mayer, 1997). This paper investigates this issue by studying the VR application that places emphasis on information integration. Next to the development of the application, it is to be evaluated in terms of its usability and learning effectiveness, given that it is crucial for an educational application to be evaluated in terms of usability and learning (Squires & Preece, 1996). A usable application allows it to be used as expected with little or no hesitation (Rubin & Chisnell, 2008). With regard to learning, it is expected that VR application would improve students' learning compared to conventional resources, such as paper-based learning materials.

A. VR Application as a Medium

VR applications can be used as a medium for a virtual field visit and also as a learning resource. To distinguish between a virtual field visits (VFV) and a non-VFV (which refers to a conventional field visit where students physically visit the related places), the non- VFV is referred to as a physical field visit (PFV). A PFV can be defined as a visit arranged *"for educational purposes in which students go to a place where the materials of instruction may be observed and studied directly in their functional settings*. PFVs are conducted in different disciplines such as earth science, geology, engineering, architecture and farm management. The visits are proposed to support students to relate what they learn in class to the physical world and are a successful and pleasant learning form. They facilitate to develop critical thinking about subjects related to the visit and increase students' productive attitudes towards science. Exposure to, and familiarity with, real-world experiences have been shown to be useful to engineering graduates. In addition, field visits facilitate students to understand concepts to a scope which is easier said than done to accomplish by means of lectures and lab work.

Exposure to the sites of field visits is becoming further complicated for reasons such as safety concerns, weather, time constraints, and more numbers of students resulting in organisational hitches and cost and effort. An option is to employ virtual field visits (VFVs). A VFV is defined as *"an expedition engaged without really making a visit to the site*". VFVs have been conducted in disciplines such as earth science, (Lin, Tutwiler, & Chang, 2011), geology (Lewis, 2008) and geography (Stumpf et al., 2008)[9]. A VFV uses a VR application to show the physical environment, presented using panoramas that presenting the physical environment. An elevated level of realism would help students maintain interest in the VFV. In addition, we suggest that the VFV needs to be linked and integrated with the core curriculum to encourage enhanced learning.

A VFV could be conducted in a 'mentor driven or 'student driven mode. 'Instructor driven refers to students not having any interaction with the medium used for the VFV (e.g., software, websites) and only watching and listening to the instructor's explanation while using the application. 'Student VFV refers to students interacting with the application during the VFV; either by themselves or with assistance or guidance from the instructor (e.g., the instructor may guide the class and provide explanations at the same time as the students are using the application). The VFV can endow with further flexibility than the PFV because it can be conducted on an individual basis or in groups, at any time and place and at the students' learning pace. Therefore issues related to time, weather, safety and health are not a concern in a VFV. However, the VFV also has limitations that include the absence of sensory experiences which hampers the real look and feel aspect. Even though a VFV could not provide the real experience of a PFV, we propose to provide a replication of the real experience in a compromised approach.

B. VR Application as a Learning Resource

Learning is *"a natural process that leads to changes in what we know, what we can do and how we behave"* (Gagné, 2005, p. 1). According to Bloom's taxonomy of educational objectives, learning can be categorised into three types: cognitive, affective and psychomotor (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956)[6]. Cognitive learning involves knowledge and the development of intellectual skills such as recall or recognition of specific facts, procedural patterns and concepts. Affective knowledge includes the manner in which people deal with things emotionally, such as feelings, values, appreciation and motivation. The psychomotor domain includes physical movement, coordination and the use of the motor-skill areas. In many studies of educational software, cognitive learning is measured by assessing students' understanding of the content information presented in the software.

VR applications can enable students with a wider exposure to learning content than conventional learning methods such as lecture notes, textbooks and other printed materials. Conventional learning resources may not be able to convey all necessary information to students in some subjects. For example, an explanation of a washing machine could only be presented via text and figures in a conventional learning resource (i.e., paper-based notes), but in a VR application it could be explained through the use of videos, animations and panoramas. Computer-based applications endow with a flexibility to develop different types of learning applications in general, including VR applications. Apart from how the VR applications are developed, each component in the application must be carefully designed, developed and evaluated to promote better learning among the users. Evaluation is one of the issues related to computer-based learning application as most of the applications are not thoroughly evaluated in terms of educational efficacy.

IV. METHODOLOGY ADOPTED

This paper focuses on using a VR application with panoramas as an option to divulging users to a physical environment (e.g., a field visit). These VR applications have been widely used in education, however less is known about integrating different sources of information, where the information is interconnected. As we are conscious of the fact that the learners learn better when the text is placed near the corresponding pictures instead of far from each other. However, caution is needed to ensure that unnecessary presentations are not included, in order to avoid cognitive overload in students. The issue addressed in this paper therefore is studying a VR application featuring information integration that is used for classroom learning and VFV. For this, two VR applications should be developed. This approach is then evaluated as a classroom learning resource and as a medium for field visits.

Since educational VR applications often have different types of information that are not well integrated and linked and not much is known about integrating different types of information, here we see an undeniable motive to develop a VR application with the integration of different types of information associated with learning content. To address the problems user studies should be conducted. Study of a VR application focusing on integration between different information formats would certainly relate to VFVs and students' learning achievements in a fruitful manner. All these aim to provide insights for the future development of similar applications. Here we portray some of the user studies. They are as follows:

Comparison of students' attitudes towards physical and virtual field visits. Student's attitudes towards virtual field visits, Comparison of students' learning achievements from the VR application and paper based materials. Comparison of the learning effects of using the VR application as a learning resource for class assessments compared with conventional printed notes.

A VFV studies needs to be conducted with the VR applications and be reviewed and presented. A summary of the virtual field visits' evaluations would reveal the outcome. Here we devise a procedure to access them. In order to acquire their learning attitude we should cluster the learners into two groups (students attended either the VFV or PFV). And before the visits, both groups should attend a session with explanations related to the sites. In the VFV session, the students should be shown panoramas projected on a large screen with explanations given by the instructor. The VFV should always begin with an introductory video. Every student should then be asked to explore the VR application of their own. They should be allowed to ask queries. Efforts ought to be taken to guarantee that the equivalent disclosure be obtained during the PFV when explored by the VFV students using the VR application.

The review of the literature associated with VR applications in education has made known that educational VR applications time and again have different types of information that are not well integrated and linked. Furthermore, when it is used as a medium for VFV, the applications are often a replication of a PFV without the information integration that could provide students with the ability to relate what they learned in class to the allied processes that take place in the physical environment. However in our work we have made it possible.

V. RESULTS AND DISCUSSIONS

Since the VR application in education has enabled the user to have greater interaction with the virtual world, their involvement is higher and therefore as a result their understanding also is higher. Owing to this rationale VR applications are realized in very many realms. Here we have considered the education domain where in meticulous study has been done on improving the efficacy of the scenes. Under normal circumstances to explain a concept we accomplish the task through an explanation, demonstration with a 2-D and with 3-D scenes. Amongst the three the 3-D scene is always better because of its impact on the user and the understanding of the users. This is proved with the study conducted on three distinct groups with the same intelligence level. These groups were administered with questionnaire and the VFT group has emerged as the top among the three groups. The following tabular column illustrates the three groups of same intelligence level undergoing training by various methods.

First Method

Comparison of students' learning outcome through the study implementing the various methodologies reveal the following findings. Tabular Column Graphical Representation

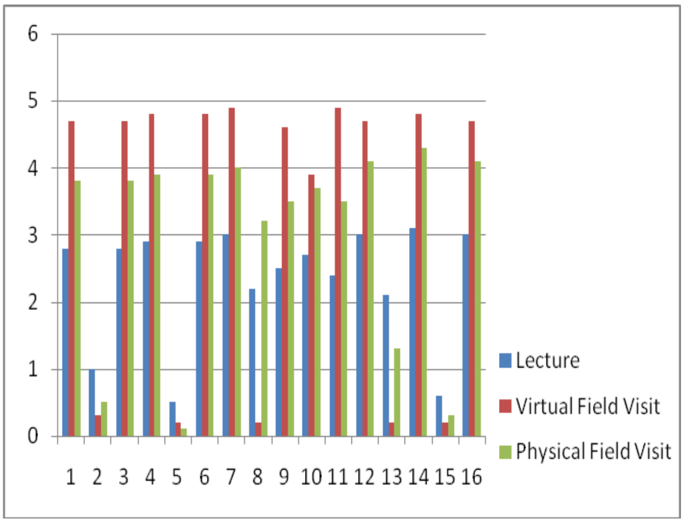

Figure: 1 Students' learning outcome being higher than the other methods adopted practically

Table: 1 Showing students' learning outcome being higher that of the lecture and PFV

RollNo	Lecture	VFV	PFV
100	2.8	4.7	3.8
101	1.0	0.3	0.5
102	2.8	4.7	3.8
103	2.9	4.8	3.9
104	0.5	0.2	0.1
105	2.9	4.8	3.9
106	3.0	4.9	4
107	2.2	0.2	3.2
108	2.5	4.6	3.5
109	2.7	3.9	3.7
110	2.4	4.9	3.5
111	3.0	4.7	4.1
112	2.1	0.2	1.3
113	3.1	4.8	4.3
114	0.6	0.2	0.3
115	3.0	4.7	4.1

Here it's a vivid portrayal of students' learning outcome being higher than the other methods adopted practically.

Second Method

Comparison of students' attitudes through the analysis conducted against Virtual and Physical Field Visits reveal the following findings. Students' learning attitude outnumber in the virtual Field visit.

International Journal of Computing Algorithm
Volume: 05 Issue: 01 June 2016, Page No. 23- 28
ISSN: 2278-2397

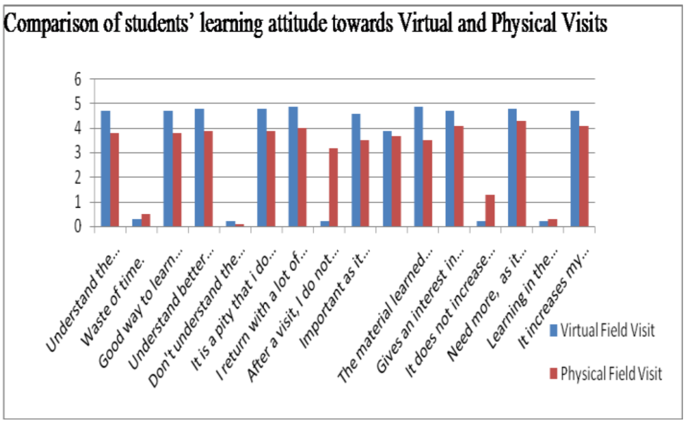

Figure: 2 Comparison of students' learning attitude towards Virtual and Physical Visits

Third Method

We have compared the students' learning achievements from the VR application and paper based materials. The result explicitly reveals that the learning gets maximized when compared among the rest of the methods.

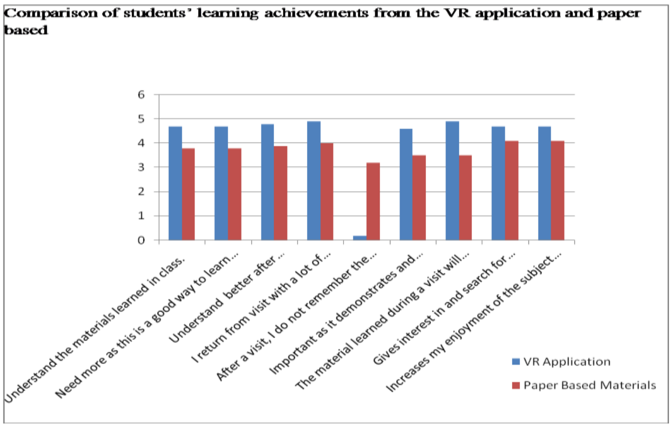

Figure: 3 Comparison of students' learning achievements from the VR application and paper based

VI. CONCLUSION

This paper focuses on issues related to using a VR application as a medium to expose students to the real world in the context of learning and acquiring practical knowledge of a site as portrayed in the virtual environment. The issues studied relate to the design of VR applications from the perspective of integrating different types of information about classroom materials and the real world. The lessons learned in this study could be used for education and training elsewhere, such as in architecture, transportation and fire fighting training; all situations where the learners need to gain practical knowledge and relate the content learned in class to the real world. The conclusions of this research have several important implications for *academics* and *developers.* The same applies to *academics.* The research findings recommend that the VR application could be used as a complement to the conventional learning approach; be it in classroom learning or for a PFV which is evident from table 1 and figure 1. For classroom learning, the learning content with less complicated diagrams or presentations could be provided using conventional paper-based lecture notes. For more complicated diagrams and explanations, the VR application could be used because it lets the students control what they want to learn at one time. The ability to control what to learn minimises the possibility of having an excess cognitive overload, which aligns with the Cognitive Theory of Multimedia Learning where the verbal and visual channels have limited capacity to process information. The features of the information integration, together with the interactive diagrams, hotspots and videos, were positively perceived by the students and they felt that these features were engaging and had helped them with better learning. Using the VR application as a preparation and revision tool for a PFV is also seen as useful because students can gain an overview of the site(s) to be visited and, therefore, gain an initial insight into what they need to focus on and pay attention to which is inferred from figure 2. Using the VR application as a revision tool allows the students to revise and obtain information that may not have been gained during the PFV because of issues such as not being able to listen to the guide's explanation or the fatigue effect from the long field visit schedule which is apparent in figure 3. The findings about people's interaction (people aspects) and career aspects provide useful insights for conducting a VFV, where a closer integration with the organisation portrayed in the VR application could be included, e.g., include the job description of the workers in the organisation and have a representative from the organisation as the guide. For *developers,* the findings from the research provide recommendations for future development of educational and training software. The feature of the VR application could be used as a basis for developing applications that incorporate multiple information sources, such as the microarray data in the area of biotechnology. Here the findings provide useful insights for people without detailed technical skills to further explore the applications for any similar development. *Future Scope* Another possible area of future research is to extend the VR application by incorporating a virtual character into the application. Since the students were interested in interacting with workers in the physical plant, and gaining information about their job scope and company profile, it would be interesting to construct a VFV using a virtual character representing workers from the company in the plant, instead of using a real person. This would allow interactive conversations between the students and the virtual character without the need to have a guide physically present during the VFV. In addition to this, another future possibility is to conduct a study on this aspect such as comparing the VR application with integrated information with another VR application having the same information without integration.

References

[1] Abdul Rahim, E., Duenser, A., Billinghurst, M., Herritsch, A., Unsworth, K., McKinnon, A., & Gostomski, P. (2012). A desktop virtual reality application for chemical and process engineering education. Paper presented at the Proceedings of the 24th Australian Computer-Human Interaction Conference (OzCHI 2012), 25-29 November 2012 (pp. 1-8). Melbourne, Australia.

[2] Abrantes, J. L., Seabra, C., & Lages, L. F. (2007). Pedagogical affect, student interest, and learning

performance. Journal of Business Research, 60(9), 960-964. doi:http://dx.doi.org/10.1016/j.jbusres.2006.10.026

[3] Ausburn, L. J., & Ausburn, F. B. (2004). Desktop Virtual Reality: A powerful new technology for teaching and research in industrial teacher education. Journal of Industrial Teacher Education, 41(4), 1-16.

[4] Bell, J. T., & Fogler, H. S. (1998). The Application of Virtual Reality to Chemical Engineering and Education. Michigan: University of Michigan, Ann Arbor

[5] Bell, J. T., & Fogler, H. S. (2004). The application of virtual reality to (chemical engineering) education. Paper presented at the Virtual Reality, Proceedings. IEEE, 2004, 27 – 31 March 2004 (pp. 217-218). Retrieved from 10.1109/VR.2004.1310077

[6] Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of Educational Objectives, the classification of educational goals – Handbook I: Cognitive Domain. In B. S. Bloom (Ed.), Taxonomy of educational objectives: Cognitive and Affective Domains. New York: Longman

[7] Bradford, G. R. (2011). A relationship study of student satisfaction with learning online and cognitive load: Initial results. The Internet and Higher Education, 14(4), 217-226. doi:http://dx.doi.org/10.1016/j.iheduc.2011.05.001

[8] Broberg, H., Lin, P., Griggs, K., & Steffen, G. (2008). Learning Styles of Engineering Technology and Engineering Students: Pedagogical Implications. Journal of Engineering Technology, 25(1), 10-17.

[9] Chang, C. Y., Lin, M. C., & Hsiao, C. H. (2009). 3D Compound Virtual Field Trip system and its comparisons with an actual field trip. Paper presented at the Ninth IEEE International Conference on Advanced Learning Technologies, 15-17 July 2009 (pp.6-7). ICALT 2009., Riga.

[10] Sangeetha Senthilkumar, Dr. E.Kirubakaran, "Enhancing E-Learning through VRML Techniques ", IJCSI (International Journal of Computer Science Issues) November 2011 Issue. ISSN (Online): 1694-0814.

[11] Sherman, W. R., & Craig, A. B. (2003). Understanding virtual reality : interface, application, and design. Amsterdam ; Boston: Morgan Kaufmann Publishers.

[12] Spaulding, D. T., & Ranney, P. A. (2008). Virtual Field Trips: Advantages and Disadvantages for Educators and Recommendations for Professional Development. In D. L.Newman, J. Falco, S. Silverman & P. Barbanell (Eds.), Videoconferencing Technology in K-12 Instruction: Best Practices and Trends (pp. 191-199). Hershey, PA: Information Science Reference.

[13] Spicer, J. I., & Stratford, J. (2001). Student perceptions of a virtual field trip to replace a real field trip. Journal of Computer Assisted Learning, 17(4), 345-354. doi:10.1046/j.0266-4909.2001.00191.x

[14] Żywno, M. S. (2003). Hypermedia instruction and learning outcomes at different levels of Bloom's taxonomy of cognitive domain. Global J. of Engng. Educ, 7(1), 59-70.