Acceptance of 3D Visualizations Methods for Learning and Training in the Area of Electrical Engineering

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Abstract - **In this paper the acceptance of computer based training in the area of electrical engineering using three-dimensional visualization methods is presented.**

At the Otto-von-Guericke-University's Faculty of Electrical Engineering and Information Technology in Magdeburg, Germany, virtual representation of a fuel cell, wind turbine and power switch by means of virtual reality modeling language (VRML) have been developed and implemented in the learning system RegEn. The RegEn special learning scenarios (modules) can be performed as a demonstration or as an interactive three dimensional (3D) training.

The RegEn is in use since 2004. Last year twenty-eight students from different nationalities and between the ages 23 and 73 participated in a pilot study concerning the acceptance of this technology in the power system teaching. The questionnaire covers issues regarding digital presentation, clarity, handling and relevance of the learning scenarios (modules) used, to evaluate the acceptance.

The specific procedure and technologies with regard to the design, development, support and acceptance of RegEn from the students will be presented in this paper.

Index Terms – electrical engineering, virtual learning and training, learning scenarios, acceptance of e-learning

INTRODUCTION

During the last few years various e-learning and new visualization methods have become an important factor in higher education and have been integrated in many university programs [1]. The goal of integrating learning and visualization methods, for example virtual reality, with traditional learning methods is to have the opportunity to display detailed specific plant situations virtually and to recreate different learning scenarios [3].

There are some essential topics involved in the development and implementation of e-learning materials: new possible teaching and learning methods, shorter study time and the chance to better organize learning with increased time and place independence [4]. These several factors need to be considered while developing or implementing university curriculums that offer e-learning based courses.

An important factor for the design of computer based training is to present the content of the learning module with as little text as possible. The use of other media information carriers like sounds, pictures and graphs can be very helpful here [5]. Sometimes there are limited display capabilities, and sometimes what can be displayed is insufficient for conveying the material in a clear and simple manner. In this instance the use of 3D visualization is irreplaceable. Three-dimension representations of objects and complex systems deliver new possibilities in a graphical presentation of information. Virtual Reality Modeling Language (VRML) technology has an important advantage for such tasks, namely its flexible operation platform, which can be easily accessed with an internet browser. VRML technology is already used in many scientific areas like medicine, chemistry, earth science and electrical engineering [1]-[2]. An e-learning module can makes it easier to learn complex correlations. This procedure can be indefinitely repeated because the access of the modules is time and place independent.

This paper presents the acceptance and use of this technology for electric power system courses, continuing education and industrial training.

LEARNING MODULES USED

In the Faculty of Electrical Engineering and Information Technology at the Otto-von-Guericke-University Magdeburg, four different learning modules were successfully realized and integrated into the program of studies [5]-[6]. The modules are online web applications that integrate desktop virtual reality technology with hypermedia to facilitate the learning of 3D geometry concepts and process. The design and development concept follows two strategies: teaching scenarios and didactic design. Our ambition was to construct the learning module so that it can be used accurately not only at the beginning of student training but also for refreshing the knowledge after some time (lifelong learning).

The following learning module was offered to the students

I. RegEn – M (Renewable Energy - Multimedia)

This is an e-learning system based on the Hyperwave platform for education. The project is realized as a group of four teaching modules:

- Module 1: Basic principles of energy production
- Module 2: Photovoltaic energy production
- Module 3: Wind as an energy source
- Module 4: The Fuel cell system

The aim of this learning module is to provide the students with basic knowledge about the concept of the global energy supply, and the possibility of using renewable energy sources and their relevance for energy supply. Additionally, the modules provide the learner with information about the most important functions and operational problems of each system. The main information carrier on this learning module is the text; all other information carriers (media) only support the text.

II. RegEn – VL – Wind (Renewable Energy – Virtual Laboratory - Wind)

This second group of learning modules is an online web application and consist of modules which are available from the main menu (start page). In order to promote the learner's skills, the e-learning system is sub-divided into three areas:

- learning section – lectures to explain theoretical correlations
- practical section – 3D virtual trainings to gain practical skills working on electrical problems and
- testing section – testing the acquired knowledge

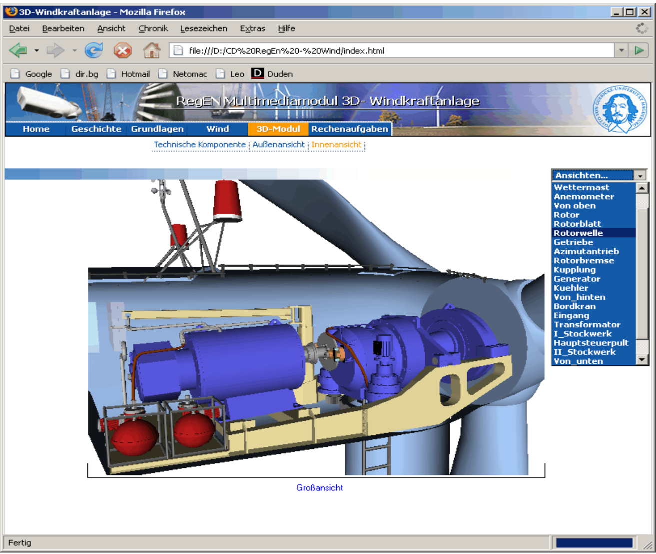

FIGURE 1
TOWER VIEW IN THE VIRTUAL WIND POWER PLANT

To complete the learning module the learner must successfully complete all three sections. During the training the learners are able to choose the structure of the wind power plant, and the whole system with its components. Here the user has a "hands-on" opportunity to examine the structure of the wind power plant by him/her self in the virtual field (Figure 1). At the same time information and data schemas for each element can be offered or requested. The student has the opportunity to learn and to see all of the specific functions of the different parts.

III. RegEn – VL – BZ (Renewable Energy – Virtual Laboratory – Fuel Cell)

The aim on this module was to create a three dimensional (3D) representation of a Fuel Cell (FC) system using Virtual Reality Modeling Language (VRML). The 3D fuel cell module was made for the purpose of a practical laboratory. When creating the virtual elements it was important to represent the models as realistically as possible. The 3D visualization shows the functions and problems that occur when using the FC equipment. The user is not only able to observe the physical processes in the fuel cell but also to put his/her own parameters on the system and change the state of the system. In this way an avatar has an influence on the virtual world.

There are three different logical parts in this learning module. The first is a theoretical part, where the user can read about the composition of the system, the operation mode and the detailed basic principles of physics and thermodynamics of the FC. The second part considers the virtual model of the fuel cell. The three dimensional fuel cell represents a fundamental configuration of the FC's components. The last section is the practical part where the learner can put his/her knowledge in to practice by building and testing his/her own virtual FC system.

IV. V.LS (Virtual circuit-breaker)

V.LS is a training module of a virtual maintenance course for circuit-breakers using 3D visualizing methods. Using these new methods, customer-specific plant situations can be represented virtually and in detail, and training periods for operators and maintenance staff are shortened considerably. The increasing complexity of technical systems, shorter innovation cycles and new global markets place increasingly higher demands on the qualifications required by service personnel. Employees must be continuously trained to be up to date, although further training must not result in long downtimes and high costs. Continuous and high-quality training, however, is required for specialized technicians in industrial enterprises. For manufacturers and operators of complex systems, plants and machines, this method permits effective training and the fast familiarization with operation, control and process sequences.

Sequences of the tutorial program are to be utilized in the corresponding course and supplement the classic attendance course methods. Each maintenance scenario is first demonstrated on the virtual model in a short video film. The user then undergoes the actual training. Supported by help functions, the user carries out the individual steps on the virtual model interactively.

This Computer Based Training (CBT) includes both video films and interactive training scenarios in German and English. It comprises two important maintenance tasks for the "Sentron 3WL" circuit-breaker:

- replacing pole assembly
- upgrading the circuit breaker to a communication capable device

PARTICIPANTS

The learning modules selected for the study combine both e-learning and traditional learning tools. Each student uses a personal computer to work by him/herself on the different learning and training modules. During the learning process a tutor was presented for questions and provided assistance as needed. All of the students are majoring in an electrical engineering field of study.

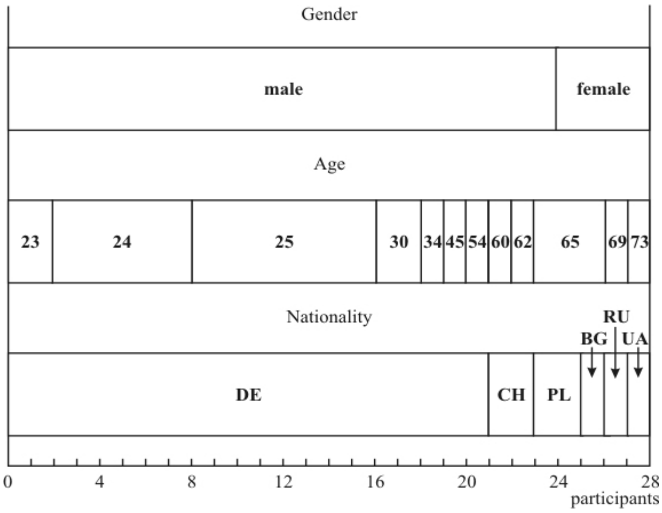

FIGURE 2
DEMOGRAPHIC PROFILE AND DESCRIPTIVE STATISTIC OF THE SURVEYED PARTICIPANTS

Figure 2 summarizes the demographic profile and descriptive statistic of the respondents. Student ages ranged from 23 to 73 years, with a participants age difference of 50 years. Students came from 6 different countries and cultural backgrounds. A written survey was made while the university was in session, parallel to the classical lectures, to get student feed-back. The survey was distributed during the lectures and was left for the students to be filled out and returned later. The students were informed that all information was anonymous and would be used to research the acceptance of the e-learning technology and the quality of the presented learning modules. All students participated voluntary in the study.

QUESTIONNAIRE

The survey questions can be split into three groups. The first group of questions indicates the student motivation and volition to use e-learning (Figure 3). The answers from the first question show explicitly that all participants have a very high volition to use interactive learning modules. Almost all of students, 25 or 96,42%, said that the use of interactive learning modules makes it possible to design better and more interesting lectures. Only 1 student disagreed. The answers to the second question are very interesting (Figure 3). When asked whether the students prefer to use interactive learning modules, instead of attending classical lectures, only 7 students or 25% said Yes and 21 students or 75% said No. The answers to these two questions lead to the conclusion that most of the students want to have and use e-learning, but not in place of traditional lectures.

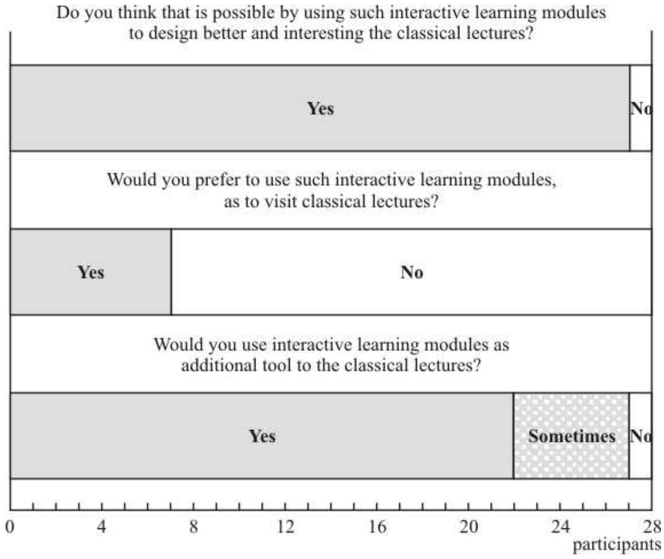

FIGURE 3
RESPONSES SUMMARIZES GROUP ONE QUESTIONS

This thesis can also be evidenced from the last question summarized in Figure 3. There 22 students or 78,57% said that they would use interactive learning modules as an additional learning and training possibility to the traditional lectures. Five students or 17,85% would use such a method sometimes, and only 1 student 3,57% would not use such learning modules as additional opportunity. These results show us that a combination between traditional lectures and additional e-learning modules is a very good alternative for most participants in our survey. The contact with the professor during scheduled lectures in combination with the time flexible e-learning module for preparation and reenactment of the learned material is a good combination.

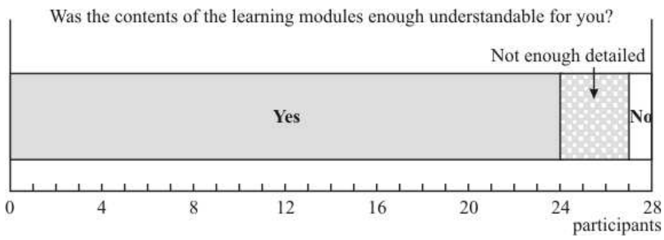

FIGURE 4
PARTICIPANTS RESPONSES OF QUESTION GROUP TWO

Figure 4 indicates the participants´ answers for the effectiveness of the e-learning course content, structure, and design from the student perspective. We can see that 24 or 85,71% of the students found the learning content clear h and detailed enough. Only a small group, 3 or 10,71%, wished for more understandable and in depth information, and only 1 student or 3,57% found the contents lacking in clarity and detail. This is a very good result, and show us that a good planning phase at the beginning of the design process for the learning modules is very important. It starts with the graphical presentation of the learning environment and includes the navigation, clearness, the structure of content and the learning method. The learning environment should motivate and activate the user and also make him/her more interested in new knowledge. A student should be curious about continuing on to the next level.

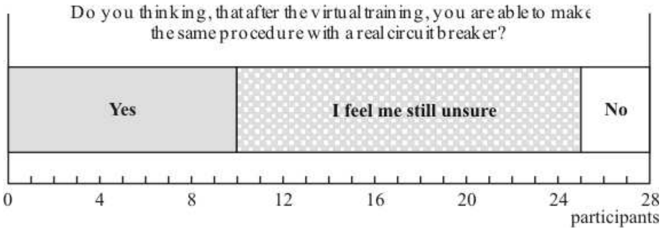

FIGURE 5
PARTICIPANTS RESPONSES OF QUESTION GROUP THREE

The last question in our survey was directed to the application of 3D geometries in the learning modules. The students were required to perform two maintenance tasks with the virtual circuit breaker: replacing the pole assembly and upgrading the circuit breaker to a communication capable device. After this module they were asked if they would be able to do the same procedure on a real circuit breaker (Figure 5). On this question 35,71% or 10 students said that they feel sure enough to perform the maintenance tasks on a real device, 53,57% or 15 participants felt unsure, and 3 students or 10,71% did not trust themselves to repeat the procedure on a real circuit breaker. One possible explanation for these results is that users with high visual spatial ability can work more easily with the virtual 3D model. Participants with high visual spatial ability spent more time on task relevant content that student with low visual spatial ability. This problem can be minimized by using the navigation tools to view the object from various angles, by loading a new virtual object, or by clicking on the object to making the selected part of the system transparent. So it is possible to focus the student's attention on some important information or objects and in this way the learning success is increased. To further increase the learning success hands on practice with the real device, in our case the circuit breaker, should also be provided. This can be also seen from the answers from the students who do not feel ready to repeat the procedure on a real circuit breaker. Breaking this engineering barrier can only be accomplished by combining virtual training with training on real devices.

CONCLUSION

The use and acceptance of computer based training in the area of electrical engineering using innovative learning and visualization methods was presented in this paper. The survey shows a high user acceptance and motivation. But informal discussion and the results of our survey showing that the e-learning and the use of 3D visualization methods is generally accepted as additional service to the traditional lectures.

The innovative e-learning technologies were involved in order to make learning in everyday life easier for students and technical personnel. Moreover, one important aspect of effective studying means that learning content is available to students on demand. Our learning platform uses the internet to reach our students and by the implementation of 3D objects with classical web learning materials like text, picture and sound we increase the regard and learning grade. The learning modules were design to support the traditional evaluated learning programs on selected topics from the area of electrical engineering. The acceptance of e-learning is expanding and will become an integral part of all aspects of future education. All learning modules have been implemented into the teaching process in a laboratory for simulation and design at the Otto-von-Guericke-University Magdeburg.

REFERENCES

[1] Bauer, P., et al., "e-Learning in Electrical (Power) Engineering, from Idea to Reality: State of the Art and Challenges", *Proceedings of the 33rd IEEE Power Electronic Specialists Conference,* Cairns, Australia, 2006

[2] Yeh, A., Nason, R., "Knowledge Building of 3D Geometry Concepts and Processes within a Virtual Reality Learning Environment", *Proceedings of the ED-MEDIA 2004,* Lugano, Switzerland, 2004

[3] Savajger, J., Valencic, V., "Discovering Electricity by Computer-Based Experiments", *IEEE Transaction on Education,* Vol. 46, No. 4, November 2003, pp. 502-507

[4] Coleman, J., N., "Effectiveness of Computer-Aided Learning as a Direct Replacement for Lecturing in Degree-Level Electronics", *IEEE Transaction on Education,* Vol. 41, No. 3, August 1998

[5] Angelov, A., N., Smieja, T., Styczynski, Z., A., Gast, C., Koenigbauer, et al., "Teaching technical personel using new 3D training modules", *Proceedings of the International Conference on Engineering Education ICEE'06,* San Juan, Puerto Rico, USA, 2006

[6] Angelov, A., N., Haubrock, J., Hadzi-Kostova, B., Styczynski, Z., A., "Learning about Renewables using VRML-Technology ", *Proceedings of the IEEE Power Tech 2005,* St. Petersburg, Russia, 2005