Learning Distributed Activities Inside 3D Virtual Spaces

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Abstract

We discuss the effects of using distributed virtual reality environments in the educational process. Pedagogical, technical and implementation aspects are explored in conjunction with a virtual environment used in the engineering training curricula.

Keywords: Virtual Reality, Learning, Teaching, Motivation.

Knowledge exchange occurs in the process of social interaction. The complexity of the actual knowledge we are trying to assimilate makes us active parts in an educational environment. Searching, discovering and testing, are the most frequent human activities in such environments. When an abstraction level of knowledge is reached, these activities are completed and creational acts may appear as complement to learning, with a constructive feedback as one of the side-effects.

In the following sections we will emphasize the contribution of distributed virtual environments to the learning process in order to transform it into an effective and evolutionary one.

1. Introduction

Many educational virtual environments are using different metaphors in order to facilitate the trainee learning on an abstract (math, physics, etc.) or concrete level (as gesture or behavior in certain situations) but few of them are taking into consideration the trainee motivation to "*do it*". Multimodal environments combining haptic feedback with

3D visualization (Hamza-Lup, 2008) prove very efficient at learning and understanding concepts. Because the environments we propose are addressing mature users, motivation may come not necessarily from the environment itself but from the user's desire to succeed in its integration within a professional context, very often being based on the teamwork concept.

As students gradually gain confidence in the team they participate in, they become autonomous and are willing to learn and acquire new knowledge; thus, they change from being dependent to being independent and the relationships between individuals becomes dynamic and warm. In particularly, this kind of environments is suitable for an interdisciplinary team. For example, the system we discuss here, EngView, was developed by a mixed team of computer scientists, engineers, and managers, as well as a group of enthusiastic students. In this way, we have attained our main pedagogical objective; that is to assure our students a rapid and successful integration in the economical context. However, some difficulty will arise due to several factors. One of the most important is the difference level of knowledge that the students attains during their studies. Another is the student level of interest in the presented information and, a factor with the same importance, the student motivation to learn.

There are different learning "speeds" and they vary from person to person. Often, theory is easier to grasp than to translate into practice. Or vice-versa, practical skills are quickly achieved, even without any basic understanding of the theory. In spite of these difficulties, we want to achieve good theoretical and practical skills employing such environments.

For theoretical knowledge level, the widely used method of multiple choice examinations can be computer graded or easily marked with a template. However this method does not provide any insight into the trainee's work methods and adaptability. A much better choice is the written examination. On the other hand, practical examinations are somewhat more probing, however the trend is to have the candidate demonstrate his skills on a simple application which can be easily and uniformly graded and which may or may not be relevant to his industry (Roloson, 2004).

Because new technologies, as virtual reality (VR), facilitate learning through the concepts construction based on the intuitions that arise from user direct experience of the virtual environment (Bruner, 1986), we have decided to complete our teaching/learning process by using these technologies. We are not eliminating multiple choice examinations, but we consider that the communication and interaction within a collaborative virtual environment may represent essential motivational dimensions of trainee experience. This makes interaction, communication and motivation to be the most important requirements of our technology.

Another important aspect is the reduced accessibility of the real setups for a group of trainees. By switching the training sessions in real environment with training sessions using virtual replicas, the trainee is able to obtain the confirmation of its practical results obtained in virtual environment. So we are not eliminating the real tests in real situations, but we let the students to exercise longer within a virtual setup, without any physical risks and at lower costs for them (and for the setup of course). When they reach a certain level of "virtual expertise", they are allowed to prove this expertise in real environment.

2. Success story

In order to demonstrate the effectiveness of such an educational virtual environment we have implemented a training environment, called EngView (CERVA, 2007) that is basically a supplementary tool in the engineering curricula training process in the domain of the non-destructive testing (NDT).

2.1. NDT principle

The most used formats in the NDT training process are A-scan, B-scan and C-scan presentations, providing different ways of visualization and evaluation of the material region being inspected. For our purposes, we have chosen to visualize only the C-scan method.

The high frequency ultrasonic C-scan presentation provides a plan-type view, depth location, and size of the defects inside the probe; this makes C-scan a valuable tool to monitor the precise location of defects between certain layers (see *figure 1*). The plane of the image is parallel to the scan pattern of the transducer. C-scan presentations are produced with an automated data acquisition system, such as a computer controlled immersion scanning system.

The C-scan method is based on the transmission of a very high frequency signal (up to 50 MHz) directed to the sample by a transducer. The sample and the transducer are submerged in a coupling medium (water in our case). The initial signal is partially reflected back to the transducer at interfaces, defects, porosities and at strong differences in acoustic impedance in the sample and the rest of the signal. If not fully reflected, the signal continues through the sample. In other words, between the initial pulse and the back wall peaks there will be an additional peak caused by the sound wave going from the water to the test material. This additional peak is called the front wall peak. The ultrasonic tester can be adjusted to ignore the initial pulse peak, so the first peak it will show will be the front wall peak. Some energy is lost when the waves hit the test material, so the front wall peak is slightly lower than the peak of the initial pulse. In return, the peak amplitudes as well as the time-of-flight of each returning signal are stored in a computer data file and processed off-line to produce maps of the scanned area for the sample placed at a particular depth.
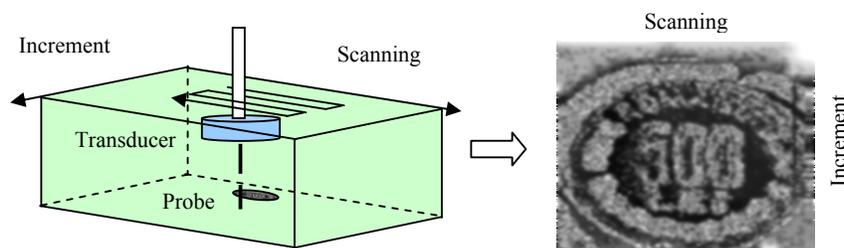

Figure 1. C-scan principle

2.2. Cooperation in a virtual environment

A predominant metaphor is the "virtual classroom". In such a classroom, we consider that organizing the learners in teams may reduce most of the gaps between the individual knowledge by increasing communication and competition (in this order). In this way competition becomes cooperation and increases the level of motivation. Hence, the complexity that may arise in "natural" ways even in the most "simple" subjects is a non-declared motivational factor when introduced gradually. Doing so, in the learning context, if the learners' needs are satisfied and their expectations are met, they will strive to develop their professional competences. Indirectly they are contributing to the development of the learning context (see *figure 2*).
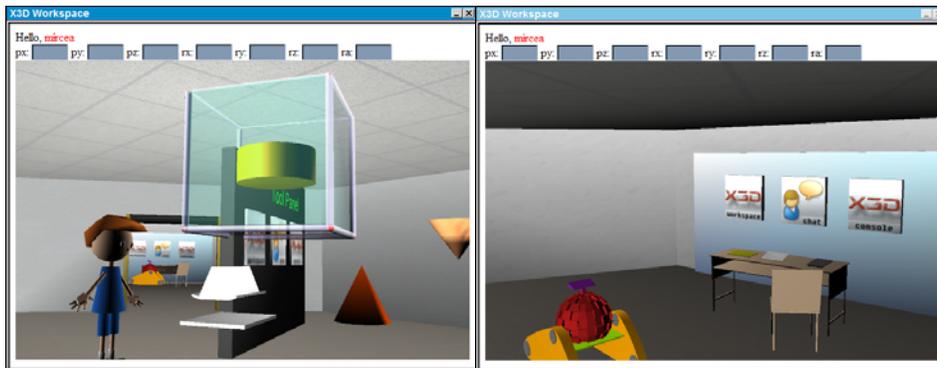

Figure 2. Sample of a shared virtual classroom

Because the students are sharing the real environment, we want them to share the same virtual environment also. Students naturally start to form small work teams in the virtual setup, bases on the real environment configuration. Later, these teams will evolve and will be based on the complementary knowledge that the team members posses, in order to assure high-level of team performance. Shared experiences provide different, perhaps even complementary perspectives to the lesson's subject, depending on each individual.

The EngView setup was used during the second semester of 2007 in training sessions by Engineering and Physics senior students, organized in 8 groups containing 25 students each. The NDT curricula require one practical evaluation on the basis of 6 laboratory hours. As mentioned before, the NDT makes no exception in both theoretical and practical evaluation. To this end, the virtual environment contains pedagogical resources that provide user access to theoretical background and evaluation as well as to practical sessions.

The theoretical exam is organized on the basis of a multiple choice test containing 10 pure theoretical and 7 practical questions (CERVA, 2007). The students have 30 minutes to answer all questions. The practical evaluation has three steps: the experiment setup/calibration; the experiment itself; and the results interpretation. In the real configuration, about 30 minutes are necessary for an experiment per student, without any

error recovery, so there is no possibility to try it twice. In this situation, it is often enough that, during the exam, the student manipulate the real NDT setup, for the first time.

Because of the time limitation and the multi-user accessibility that a real configuration presents, we decided to implement our own 3D-immersive simulation software, EngView. By implementing all the functionalities of the real NDT installation, the EngView allows the user to practice within an interactive 3D simulation of the real environment.
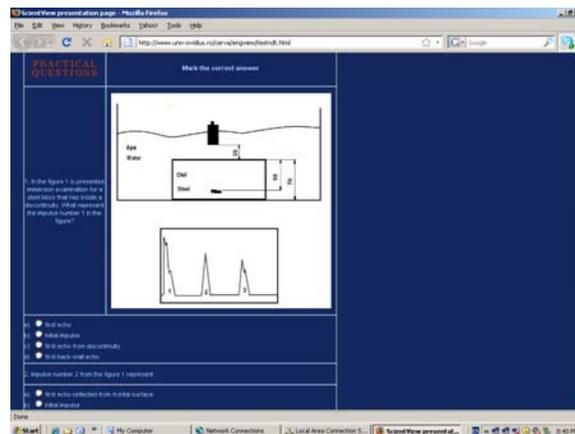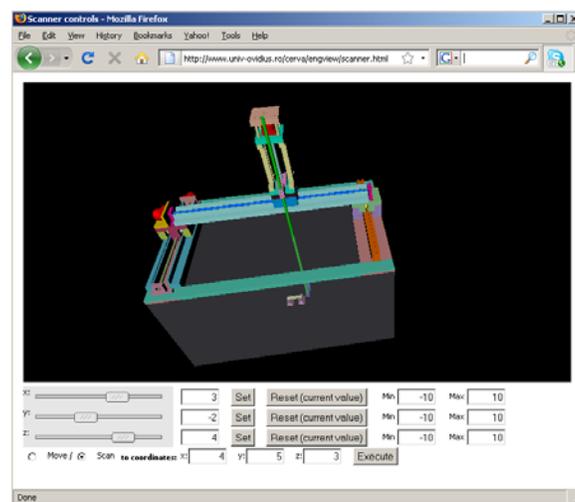

Figure 3. EngView – theoretical session (grila)

Figure 4. EngView – practical session

More precisely, the user is able to freely change the viewpoint inside the simulated environment (front/back, left/right, up/down), as well as s/he may chose to navigate through the simulated environment attached to the scanning virtual devices. This feature

allows the user to visualize the surface of the virtual scanned object during the simulation. S/he can also move the three crane-like components of the virtual scanning device, in order to virtually scan the simulated 3D object.

Students can reproduce different types of a real experiment using the EngView system (preparing the sample, installing the type of transducer, setting the parameters of moving engines to establish the type of scanning procedure). In order to realize a comparative study, the user may choose even a particular moment in time. This way, the students that work on the clients PC in EngView system are able to make the same kind of analysis as in a real system.

The EngView system could be used independently, not coupled to the real system, by installing it on a PC. This is an advantage since it allows students to train individually using their home computer and an Internet connection.

We can observe (*Figure 5*) that keeping only the traditional training sessions (in blue) is both non motivating and time-consuming. The possibility of failure because poor practical skills and/or because of errors that may appear during the experiment is too high for the current curricula. On the other hand, offering students the possibility of practicing in a virtual configuration before the real one (in violet), we have succeed in motivating them to prepare themselves. The students became more confident in their potential due to the possibility to recover from errors and to experiment more training situations using the virtual setup.
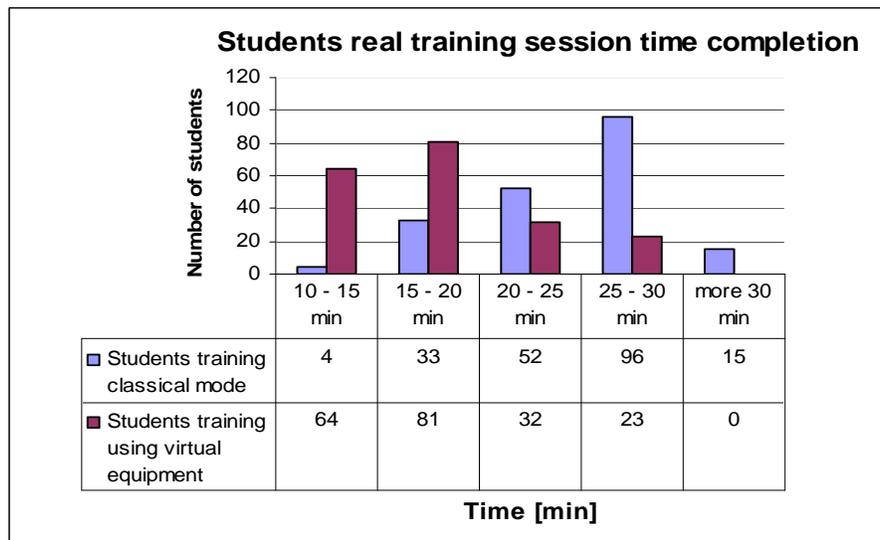

Students real training session time completion

	10 - 15 min	15 - 20 min	20 - 25 min	25 - 30 min	more 30 min
▫ Students training classical mode	4	33	52	96	15
▪ Students training using virtual equipment	64	81	32	23	0

Time [min]

Figure 5. Students training time completion in real configuration without virtual training sessions (▪), and with virtual training sessions (▪)

In addition, the amount of training hours and practice established by regulations could be considerably reduced. It makes seminars less expensive by using complex immersive and interactive simulation with on-line tests. Moreover, it brings students

closer to the practical part of their education and helps them acquire complete comprehension of each method. This way, students will be able to do the job as soon as they start working as employees.

3. Implementation issues

Our educational virtual environments are currently based on the assumption that knowledge or skills acquired in a VR-based experienced environment will be transferred to the real world. The effectiveness of such an experience depends on the user's capability to apply knowledge or skills acquired in both theoretical and practical mixed experience VR to its real world counterpart.

The current learning materials are implemented using Moodle platform for the text and multimedia resources (Word, PDF, PPT, AVI or JPEG files) as well as 3D virtual environments.

Concerning text-based and multimedia supports, we are exploiting the Moodle (Moodle) facilities in order to align the pedagogical context to Sharable Content Object Reference Model norms (SCORM). Moreover, we manage the users access to the corresponding course materials, according to their curricula, and also the course materials. This means that the tutors have the functional possibilities to create, modify and publish educational materials (courses, seminars, home works, project subjects, tests, others). Moreover, using such a system, the administrator is able to manage the courses, the users, the groups of students, as well as the students enrolling in a specific courses.

The 3D environments are developed basically based on VRML (VRML) and/or ARéVi API (Reignier et.al., 1998). ARéVi API has the advantage of being an open source; it is C++ and OpenGL based, and is adaptive to very different configurations starting from desktop systems, and ending with 3D stereoscopic immersion systems. In order to put all together, we are using a reactive agent-based architecture (Popovici, 2004). This architecture assure the user immersion and evolution within the virtual space.

In order to ensure the distributed activities we have adopted the LAMP architecture; i.e. Linux, Apache (Apache), MySQL (MySQL) and PHP (PHP) solution. Because our educational environment is mostly 3D-oriented, we chose to create its architecture based on the Ajax technology and X3D/VRML language. Ajax provides optimum update speed between the client and the server by simulating a direct connection, while X3D has the advantage of having an accessible structure that can be controlled from within the Javascript (X3D). PHP and MySQL make the backbone of the whole application, being the parts that are in charge of the user account and database management.

4. Conclusions

Many educational virtual environments are using different metaphors in order to facilitate the trainee learning on an abstract (math, physics, etc.) or concrete level (as gesture or behavior in certain situations) but very few of them are taking into consideration the trainee motivation to "*do it*".

Within a group of children, each child contributes with its' knowledge to the others children's knowledge, as (Johnson, 1999) suggested, cooperation between children in virtual environments may have a positive effect on learning.

Because narrative lends itself to active exploration of a domain through challenging and enjoyable problem-solving activities, (which are essential for learning) the children develop communication and cooperation skills by invoking a narrative or game-like context (Wood, 1996). Moreover, Internet, multimedia, VR and augmented reality (AR) technologies are now part of our everyday life. These technologies facilitate learning through the concepts construction based on the intuitions that arise from our direct experience of the VE (Bruner, 1986).

We consider that the communication and interaction within collaborative multi-cultural VEs are the most important motivational dimensions of user experience.

5. Acknowledgements

REFERENCES

Apache, http://www.apache.org
BRUNER, J. (1986), *Actual Minds, Possible Worlds*, Harvard University Press, Cambridge, MA.
CERVA, http://www.univ-ovidius.ro/cerva/engview , 2007.
HAMZA-LUP, F. G., SOPIN, I. (2008), *"Haptics and Extensible 3D in Web-Based Environments for e-Learning and Simulation"*, 4th International Conference on Web Information Systems and Technologies (WEBIST), May 4-7, Funchal, Madeira, Portugal.
MySQL, http://www.mysql.com
Moodle, http://moodle.org
PHP, http://www.php.net
POPOVICI, D. M. (2004), *Modeling the Space in Virtual Universes*, PhD Thesis, Politehnica University of Bucharest.
REIGNIER, P., HARROUET, F., MORVAN, S., TISSEAU, J., DUVAL, T. (1998), *ARéVi: A Virtual Reality Multiagent Platform*, Lectures Notes in Computer Science, Volume 1434, ISSN: 0302-9743 (http://www.cerv.fr/fr/activites/AReVi.php).
ROLOSON, C., ZIRNHELT, J. (2004), *Performance Based Qualification: an NDT Service Industry Perspective*, paper no. 744, CD-ROM proceedings of the 16th WCNDT 2004 – World Conference on NDT, Aug. 30-Sep. 3, Montreal, Canada, http://www.ndt.net/abstract/wcndt2004/744.htm
SCORM, Sharable Content Object Reference Model, http://www.adlnet.gov/scorm/
VRML, Virtual Reality Modeling Language, http://www.web3d.org
X3D, http://www.web3d.org