USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN TRAINING. EXPERIENCES, ADVANCES AND TRENDS

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Tecnatom has carried out for the last seven years developments and investments to use Information and Communication Technologies (ICT) in training areas. This paper presents, from a chronological perspective, Tecnatom's representative experiences when implementing solutions and methods. Firstly, a brief explanation of a Training Management and Training Area Intranet application is provided, to focus next on the e-learning approach which has been followed to develop Tecnatom's Virtual Campus. Finally, the paper describes summaries of some interesting and innovative R&D projects for application of virtual and augmented reality to training, and the development of new e-learning courses in the area of maintenance. These projects are the following: VIRMAN, Spanish project to use virtual mock-ups in training; STARMATE, European augmented reality application for training and guided maintenance; PRVIR, virtual reality application for training in radiological protection; SIMU2, virtual reality application for training O&M personnel in radioactive environments.

INTRODUCTION

The development of information and communication technologies (ICT) is having a significant impact on the world of education. Over the last 6 years, Tecnatom has been developing different products that can be divided into the following areas:

- Tools for developing didactic material.
- Electronic platforms for carrying out training actions.
- Tools for organizing, managing and recording product and training action contents, as well as for knowledge management.

This article describes relevant actions in these three areas. Obviously these actions have required more flexible and open environments, which are being increasingly accepted and used.

The first of these actions was to set up the Training Intranet, which is now fully implemented. This is a management tool of systematic training programs that covers both technical and methodological aspects, as well as those related to the training service. It is in itself a powerful knowledge management tool.

The growing degree of acceptance and use of electronic courses because of their flexibility, which makes it possible to acquire knowledge regardless of time or place, led us to take the next important step, which was to develop and implement an e-learning platform that we have called Tecnatom Virtual Campus. This is an Internet portal where courses from our catalog that have been adapted to the electronic training environment are currently supported and offered. We are in the process of developing and adapting courses to this environment. These include complete training programs on nuclear, thermal and combined cycle plants, radiological protection, non-destructive testing and, finally, courses for training maintenance personnel.

This article also describes actions and participation in projects fundamentally based on the application of virtual reality to training for the purpose of developing new didactic aids. Brief mention is made of a Spanish project for maintenance activity training using Virtual Reality techniques (VIRMAN), a European Augmented Reality project (STARMATE), a project for Radiological Protection training (PRVIR), and another project for training maintenance personnel in radioactive environments (SIMU2). All these projects have created a technological core that is sufficient for implementing an action plan of specific virtual reality applications in training environments.

TECNATOM INTRANET

The purpose of developing an Intranet in Tecnatom for the training area was to centralize all information and documentation needed by the teaching staff to conduct its activities, including the following sources:

- Information/documentation not managed or drawn up by the training area, such as plant reference documentation, quality procedures, Internet links, etc.
- Information/documentation managed and developed by the training area, such as courses, didactic units, figures, pedagogic support material, presentations, question databanks, programs, timetables, etc.

The training Intranet assists training personnel when:

- Making searches of information and documents for their activities.
- Making searches of official documentation developed by the training

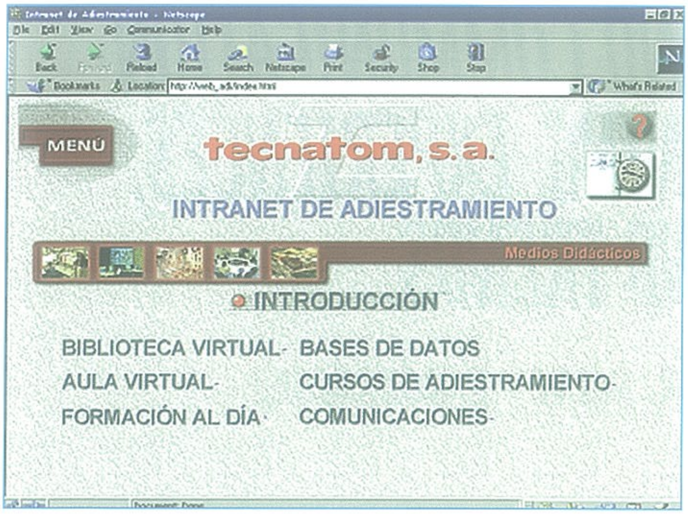

Figure 1. Main Menu.

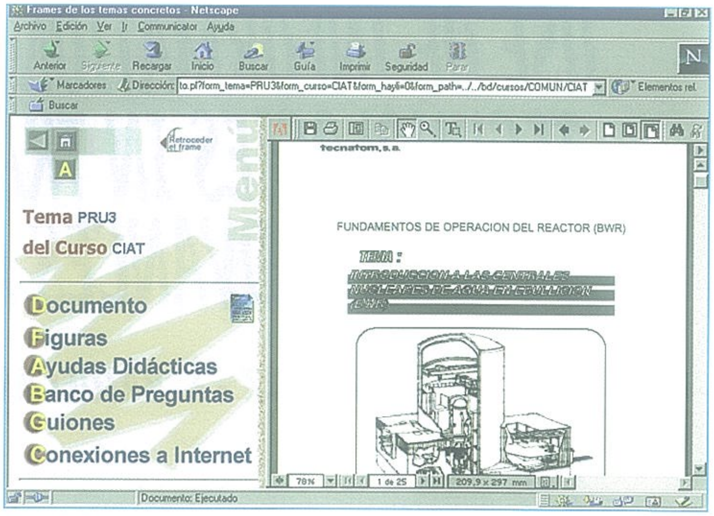

Figure 2. Database Menu.

area: courses, didactic units, figures, question databanks, etc.

- Accessing or using information prepared and developed by training personnel: pedagogic aids, presentations, exams, evaluation certificates, timetables, summaries, questionnaires, reports, training-related records, class scripts, etc.
- Preparing the scripts for classes.
- Managing relevant training records.
- Controlling modifications that affect official documentation.
- Documenting the projects developed by the training area.

The application can be accessed from any Internet navigator and, as shown in Figure 1, has the following seven main options:

- Introduction
- Virtual Library
- Training Courses
- Virtual Classroom
- Databases
- Up-to-date Training
- Communications

Of particular interest for the instructor's daily work is the Database option (Figure 2), which provides access to the different types of information/documentation managed by the training area.

The functions available in these option are:

- Courses
- Figures
- Didactic Aids
- Question Databank
- Presentations
- Training Projects

When one of these options is selected, the corresponding search formats are displayed. The fields will vary depending on the selected option.

Once the search has been defined and executed, the results obtained are presented as shown in Figure 3.

The Virtual Classroom option helps instructors prepare and give classes, manage the associated records, control the modifications that affect training documentation, and describe in detail those projects carried out in the training area.

The available options are shown in Figure 4.

Course-related information is divided into two major groups: general documentation applicable to the course as a whole (general documents, aids, programs, summaries, exams, etc.), and documentation for the specific didactic unit (document, figures, question databank, scripts, etc.).

The course management option includes three sub-options: course management (contract, customer, place, dates, instructors, required media, reports, etc.), student management, and customer management.

VIRTUAL CAMPUS

The implementation of online training, e-learning or electronic training en TECNATOM has pursued an overall technical positioning in this environment aimed at:

- Promoting cultural exchange in the training area.
- Addressing the technical, methodological and service issues associated with emerging electronic training environments based on Information and Communication Technologies.
- Using state-of-the-art electronic training tools and platforms.
- Supporting the development of new training environments integrating electronic training, simulation and advanced man-machine interface technologies.

When learning-oriented media are to be offered via Internet, two basic issues must be considered:

- The training material must not only be accessible, but must also be suitably organized and structured. Today there is a profusion of information available in Internet and in intranets, but it is basically unprocessed. Without a structure, this material is only as good as it is accessible.
- On the other hand, a process is required to guide the student through this study material.

The implementation of electronic training strategies in TECNATOM has focused on the Virtual Campus design and development project. Starting with the preparation of a didactic transposition methodology for converting presence contents into electronic training contents and the development of prototype courses, this project has progressed to a phase of course and training plan development for the TECNATOM Virtual Campus, both in the corporate environment and for the electrical sector.

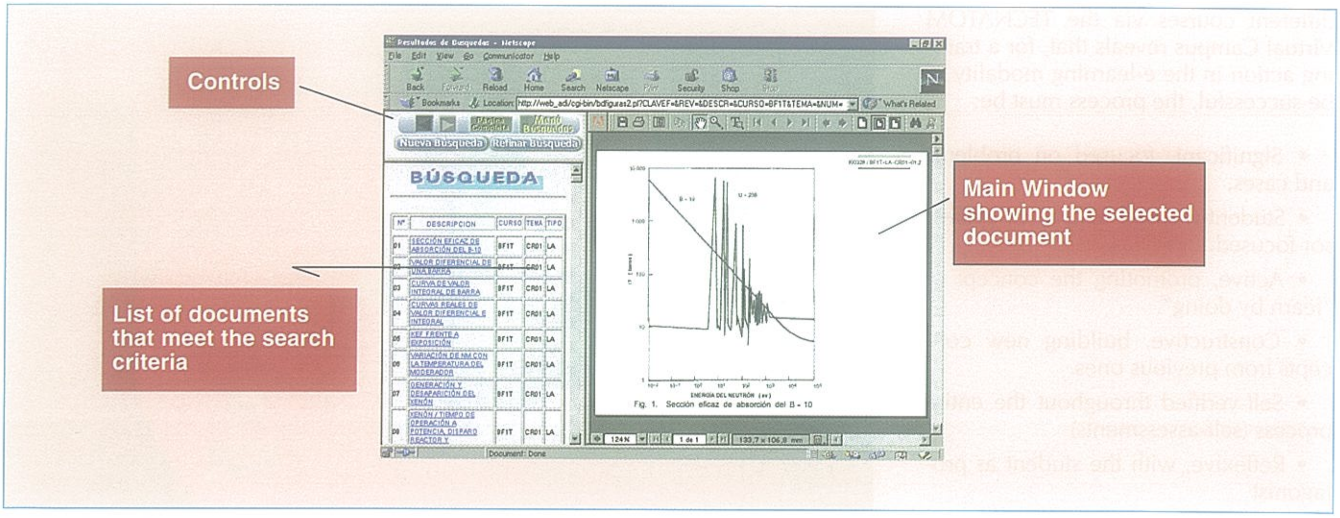

Figure 3. Search Format.

The TECNATOM Virtual Campus (Figure 5) – Tcampus - www.tcampusvirtual.com – contains a wide range of resources for strengthening mediation in the virtual classroom, controlling the teaching and learning processes, and stimulating students via a system that includes the following elements:

- Virtual study room
- Direct exchanges with professors
- Teamwork
- Self-assessment room
- Exam room
- Internal Campus mail
- Mail lists
- Administrative support
- Surveys (Students, Professors, Courses)
- Debate rooms – Online tutorials
- Course-linked debate forums
- Knowledge base
- Auditing functions
- Bulletin board
- Help
- Etc.

The Tcampus provides easy access to the different training materials and permits the following:

- Navigate from a specific training need to specific material in a hierarchical, organized structure.
- Offer training plans to certain audiences or offer specific packages to individual students.
- Make searches of the different courses available.
- Provide information on what is happening on Campus.
- Feedback to the student concerning doubts and comments that may arise.
- Contextually help the student to navigate through the campus.

Online courses in the following areas, among others, are currently available in the Tcampus: electric power generation plants (nuclear, thermal combined cycle, hydraulic), radiological protection, maintenance, non-destructive tests, etc.

The experience gained from giving

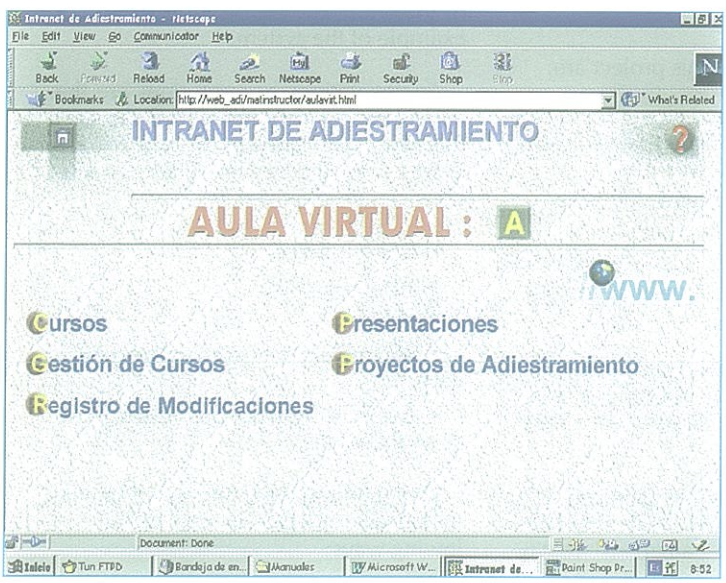

Figure 4. Virtual Classroom.

Figure 5. TECNATOM Virtual Campus.

different courses via the TECNATOM Virtual Campus reveals that, for a training action in the e-learning modality to be successful, the process must be:

- Significant, focused on problems and cases.
- Student-focused instead of professor-focused.
- Active, promoting the concept of "learn by doing".
- Constructive, building new concepts from previous ones.
- Self-verified throughout the entire process (self-assessments)
- Reflexive, with the student as protagonist
- Cooperative, learning with others.

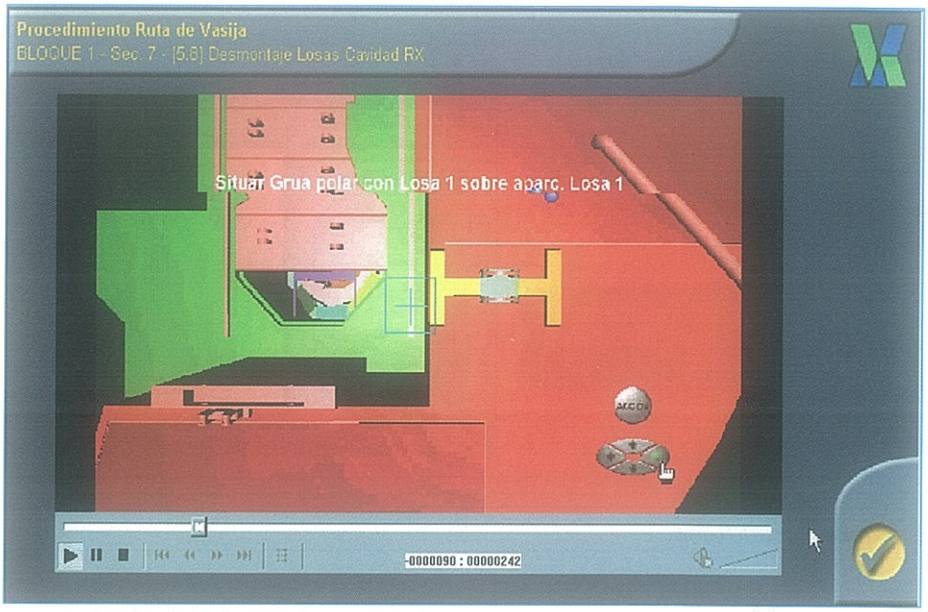

Figure 6. Virtual Reality. Trillo NPP Containment Building.

APPLICATIONS OF VIRTUAL REALITY TO TRAINING

Virtual Reality is a tool with tremendous potential in the maintenance training area. Even more important is that it is used on simple platforms with very few hardware and software requirements, and thus these tools are very flexible and reconfigurable. They are potentially capable of accommodating specific needs.

Project VIRMAN. Virtual Mock-ups for Maintenance Training

The purpose of project VIRMAN is to develop a maintenance course based on virtual image animation in three dimensions for equipment assembly, disassembly and handling. It involves modeling equipment, rooms, buildings or equipment parts in three dimensions and animating them. Each course is presented to the students through sequences and actions that represent a specific maintenance procedure or task. Virtual image animation, supported by photographs, videos, texts, messages or warnings, is used to develop easy-to-maintain courses with a high didactic value.

The system has been specified as having three operating modes:

- Operation in automatic mode. The system shows the student the procedure sequence and steps, with explanations and aids for performing the maintenance intervention or task.
- Operation in training mode (Figure 6). In this operating mode, the student practices execution of the task by following the steps of the procedure. In this mode, the system informs the student of any errors made.
- Operation in evaluation mode. Without any help from the system, the student must execute the procedure and a record is made so the instructor can evaluate the learning curve and the degree of qualification achieved.

The procedure chosen as the pilot scenario and demo of the tool's potential has been the vessel path of Trillo NPP refuelings. In this scenario, the containment and the equipment/tools that are moved during refueling operations are modeled. The sequence of actions taken during the refueling is described in accordance with the specific plant procedure.

The participants in this project are:

- Decoroso Crespo Laboratory of the Computer Science Department of Madrid's Polytechnic University.
- Empresarios Agrupados (EE.AA.)
- Trillo I NPP, as the pilot plant
- Tecnatom[1] (originally Agrupación Eléctrica para el Desarrollo Tecnológico, A.I.E.-DTN).

Project STARMATE. Application of Augmented Reality to Training or as a System for Assisting Maintenance Task Execution

Augmented Reality has emerged as a development of the Virtual Reality concept. The aim is to "augment" reality with additional information. Real objects are being seen and interacted with, but the system provides additional information (virtual) that assists or amplifies (augments) the reality and facilitates task execution or learning.

The student or maintenance technician has a system (Figure 7) composed of special goggles that allow him to see reality and that in turn act as a computer monitor. A microphone and earphones are also used to provide the aids and guidelines for executing the operation. With his hands free to do the work, the user interacts with the system by a voice recognition system and receives instructions to perform the job in the form of virtual images; these can be audio or video documents, texts or graphics. The photograph shows an example of the system.

Augmentations or restitutions are the terms used to denominate all the aids that the user, student or worker receives from the system. These restitutions can be classified as:

- Text messages
- Images/graphics
- Videos
- 3D models of equipment pieces or parts
- Audio. Coded sounds, instructions or explanations.

Visual restitutions can be displayed in the user goggles in one of the following ways:

(1) This development has used tool VTR (Halden Virtual Reality Toolkit), developed by the Halden international project, of which TECNATOM is a member.

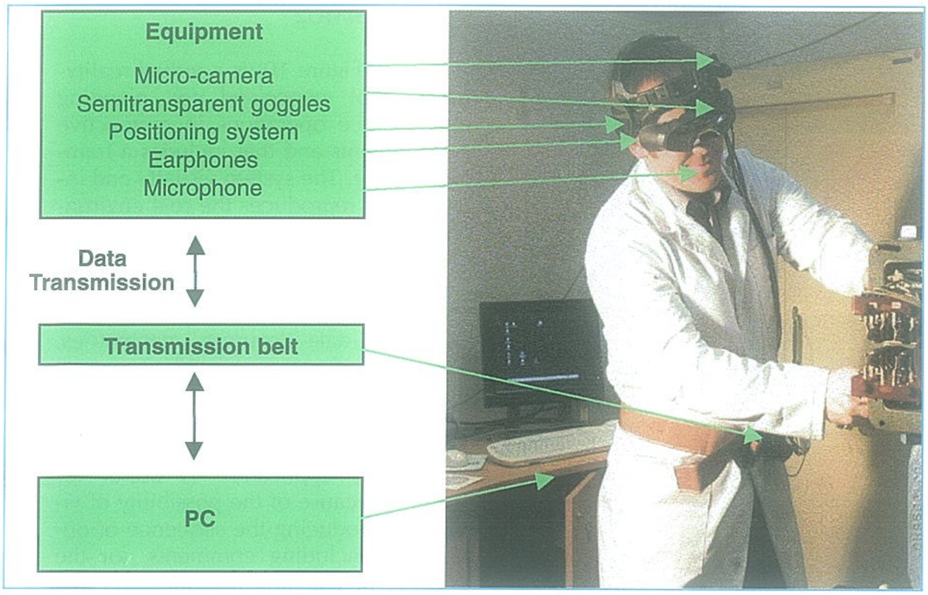

Figure 7. User Equipment and Starmate System.

• Referenced to the equipment. The image displayed in the goggles behaves as just another equipment part. This type of restitution appears as fixed at a specific point of the component and does not move when the operator moves. A positioning system (explained below) is provided for this purpose.

• Referenced to the operator, so that they move when the user moves his head. The images are followed with the eyes.

• Referenced to the environment. These images become another object in the environment in which the operator is working.

Figure 8 shows examples of the above. The system can, in one part of the reality, display a wiring diagram, an oscilloscope output, the maintenance procedure, manufacturer drawings, etc.

As mentioned above, a positioning system is used to provide information on the coordinates of each part of the equipment being maintained and the operator's position. In this way, virtual images can be represented over reality. This is a fundamental utility of this system, as it marks equipment parts and helps the user to execute the maintenance operations.

Figure 8 shows examples of what the operator would see in the goggles. Arrows are superimposed over the real object to indicate what screws should be loosened. By means of the positioning system, these arrows always remain in place indicating the screws, regardless of the user's movements and position. In addition, information or instructions on the tasks are received in audio or text box form.

There is a virtual pointer in the form of a laser ray that is beamed from the center of the user's forehead. It is seen only by the user and when he wishes. With this pointer, the operator/student can designate a part of the equipment or select one of the restitutions (windows) to ask for new aids or move the restitutions.

A 3D navigation menu is shown to the user in the goggles which shows the current step and action in a scenario, course or maintenance operation. It shows the remaining steps, the number of actions in each step, the estimated duration of each action, the time spent up to that point and the remaining time.

The system and user interact via voice, so that the student or worker can keep his hands free for executing the task. There is a voice recognition system so that all interactions with the system are made by voice-given orders. Simple keywords have been established to carry out the actions, such as "next step", "previous step", "step 4", etc.

Another system facility is the ability to store user notes. At any time, or when the operation so requires, the user is able to record information or the data required to subsequently prepare a report on the intervention. This facility can also be used to ask questions during a training evaluation process.

The STARMATE project has been developed as part of the European IST (Information Societies Technology) program which is jointly paid for by the 6 partners: Thomson, CSII, ZGVD, Dune, CASA and Tecnatom. It lasted three years and was begun in January 2000.

Project PRVIR

PRVIR (Figure 9) is a computer-assisted training course on radiological protection. In keeping with recent standards in this area, it includes two modules: generic training (notions of radiation, shieldings, measuring units and devices, etc.), and specific training (focused on the characteristics and procedures of a specific nuclear or radioactive installation). A course has been conducted for Vandellós-II NPP as a demonstration.

After receiving instruction on the pertinent concepts, the student is required to execute a series of practical exercises. Whereas the practical exercises in

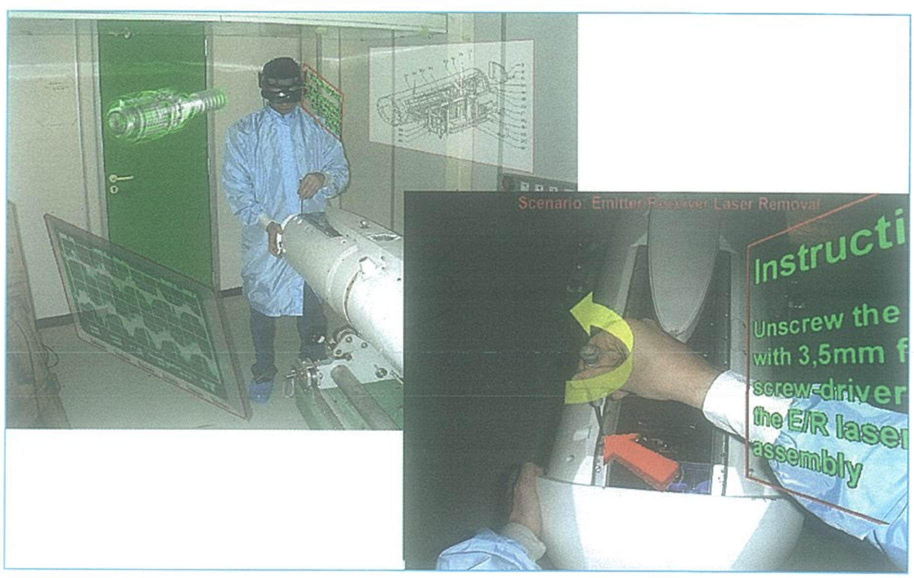

Figure 8. Augmentations Seen by the Starmate User.

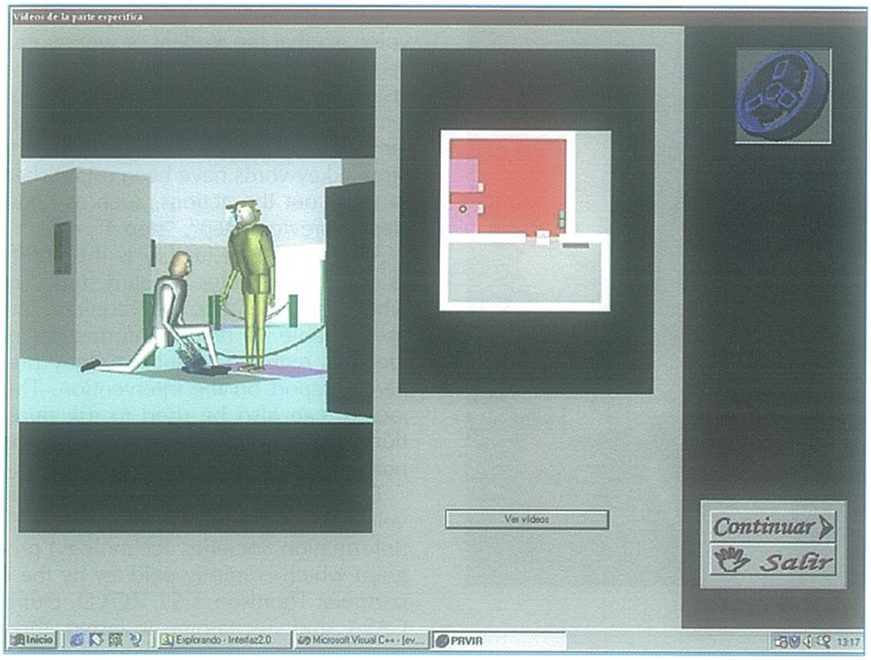

Figure 9. Project PRVIR.

module 1 (generic training) consist of a battery of questions, in module 2 the specific physical environment (Vandellós-II in the prototype) and the activities to be carried out are shown in interactive 3D format (virtual reality). The student then reconstructs the previously displayed animation by using a dummy. The system provides a step-by-step report on whether or not the simulated action is correct.

The project participants are:

- Decoroso Crespo Laboratory of the Computer Science Department of Madrid's Polytechnic University.
- Vandellós-II, as the pilot plant
- Tecnatom (originally Agrupación Eléctrica para el Desarrollo Tecnológico, A.I.E.-DTN).

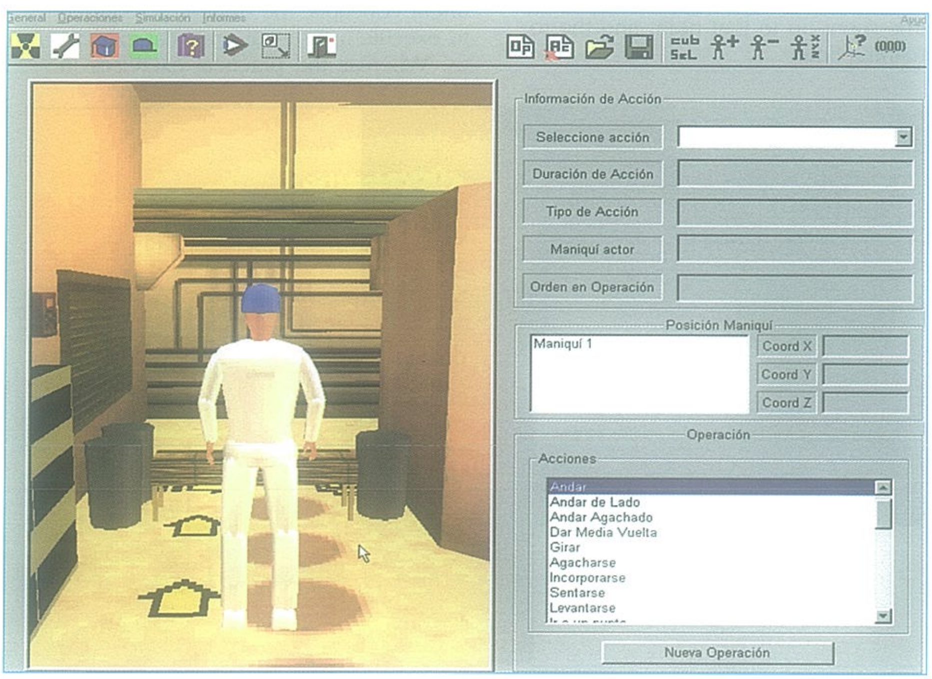

Figure 10: Project SIMU2.

Project SIMU2

SIMU2 (Figure 10) is a virtual reality-based tool conceived for planning maintenance operations in radioactive environments and that includes a training module. The system visually and interactively reproduces the real environment where the operation is going to take place and, by means of a series of tools, it can simulate human actions represented by dummies. On inputting the right data (sources, geometries, shieldings, doses measured at several points), the program calculates the dose that the operators would hypothetically receive on executing the simulated tasks. This application is useful for training because of the possibility of visually reproducing the sequence of operations, including comments, for the purpose of teaching the operators that will actually be executing them;

- Decoroso Crespo Laboratory of the Computer Science Department of Madrid's Polytechnic University.
- CIEMAT
- Almaraz Nuclear Power Plant, as the pilot plant
- Tecnatom (originally Agrupación Eléctrica para el Desarrollo Tecnológico, A.I.E.-DTN).

ACTIONS UNDERWAY

Development of Training Courses on Maintenance for the e-Learning platform Tecnatom Virtual Campus

As part of a phase of growth of our Virtual Campus course offerings, an investment project has been undertaken for the purpose of developing courses for training maintenance personnel. The first development has been a centrifugal pump maintenance course. The ultimate goal is to continue along these lines and offer a wide range of training courses in mechanical, electrical and instrumentation & control specialties. The project will be carried out over several years.

All problems associated with centrifugal pumps are addressed with text supported by photographs, animation, visual effects and illustrative videos (Figures 11 and 12), which help the student acquire the desired know-how and achieve the general objectives.

To control the learning process, interactive activities are included to check the level of understanding attained (Figure 13).

The model does not ignore the figure of the teacher, but rather leverages this

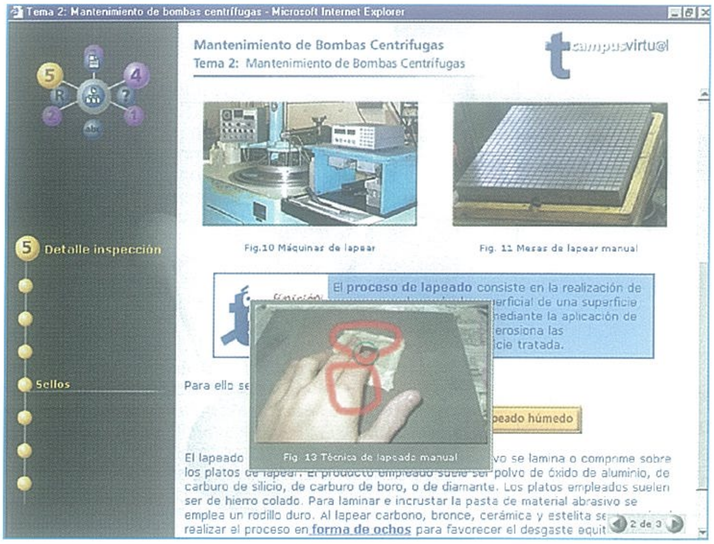

Figure 11. Centrifugal Pump Maintenance Course on Tecnatom Electronic Training Platform.

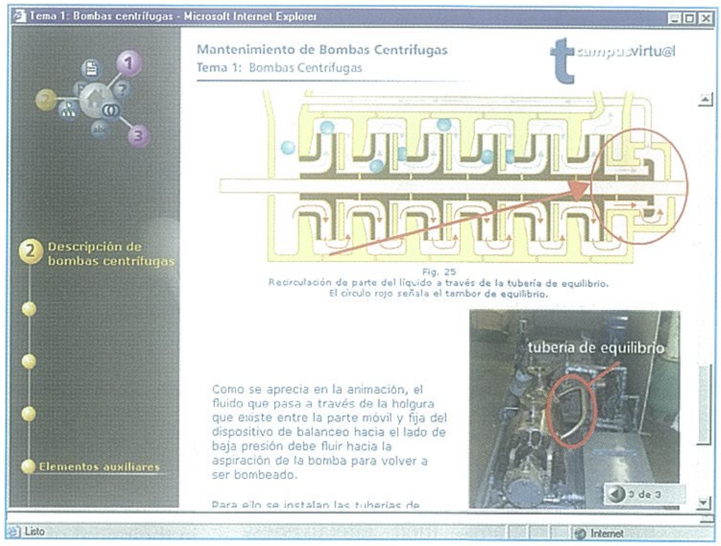

Figure 12. Centrifugal Pump Maintenance Course.

figure as a motivating element and as a way to create novel communication links that animate study.

This first subject has been completed and is now available at TECNATOM site http://www.tcampusvirtual.com. The next step being taken is to develop an instrumentation & control course called "general instrumentation maintenance course".

Virtual Reality Plan

Aware of the potential of the virtual reality technology, TECNATOM is developing an internal plan for the purpose of structuring the know-how available to date and acquiring new skills and means to exploit and drive this technology, both in traditional activities and in new activities that may be of interest to the company. As part of the scope of this action plan, an engineer is on temporary assignment at the Halden international project in Norway, a leading-edge institution in this field and in nuclear technology.

Up to 14 possible developments have been identified in the areas of training, radiological protection, simulation, maintenance, non-destructive testing and man-machine interface design. It is expected that, as a result of this plan, new products and services will be launched on the market, in this case specifically related to training.

CONCLUSIONS AND DEBATE

Very important steps have been taken in recent years that, in some cases, are hard to assimilate in such a short period of time. The rapid evolution of ICT with new advances, capabilities and products poses tremendous challenges and risks to companies that provide training. Adapting to these changes, creating knowledge in this new environment and optimizing the value offered by electronic media, increasingly require more capabilities and investments.

Obviously, ICT offers a valuable potential for training in all the areas mentioned in this article: as tools for developing better didactic material, creating new flexible, open training environments, providing optimized knowledge management, and creating simple forums for debate and exchange of ideas. Nevertheless, the methods and formulas for creating them are not developed and standardized. The ability to provide customized training, in any place and at any time, is very appealing and paradigmatic, but it is still not a reality. The existence of means does not ensure that knowledge will be acquired; we can electronically connect to people, but forums for debate are not established; we have tools for exchanging and collecting information, but there is no culture of knowledge creation and standardization.

Figure 13. Centrifugal Pump Maintenance Course. Interactive Games to Reinforce Learning.

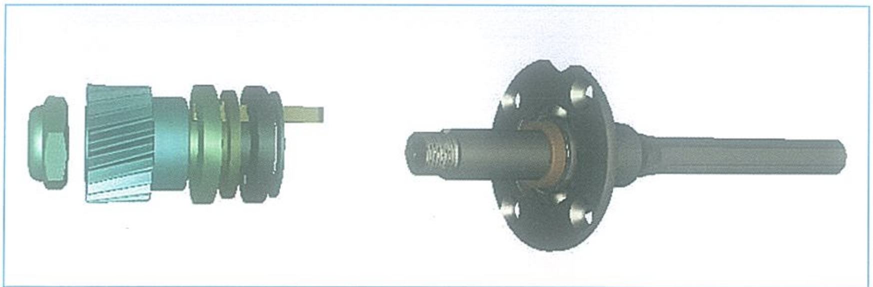

Figure 14. Virtual Reality Plan. Development of 3D Didactic Media.

All the projects in these areas obviously offer added value by generating greater transparency, quality and dissemination of training offerings.

Specifically, as regards electronic training programs, their effectiveness depends on the degree of development and imagination used. It is evident that the pedagogic use of electronic training makes it possible to acquire high quality knowledge for easily executing a task. Electronic training is increasingly used in companies to provide personnel with the necessary know-how. But it is also evident that technology will not succeed in replacing teachers. The didactic methods followed in electronic training systems are developed by educators or training specialists, and success depends on the quality of their work.

Another major challenge faced in the educational environment are the changes required in teaching staff functions. The teacher or instructor must evolve from the function of a supplier or transmitter of content to playing a guidance role and supporting students in their goal of acquiring skills.

In conclusion, the use of Internet as a platform for supporting electronic training is increasing, and innumerable uses of ICT in training and educational scenarios are emerging. These advances are clearly positive and provide added value to training, but an effective, stable and economically profitable offering must be suitably designed and developed with innovative, first-rate pedagogical methods, without forgetting that the teaching staff has to adapt to this environment. This will all lead to a successful consolidation of ICT in the training environment.

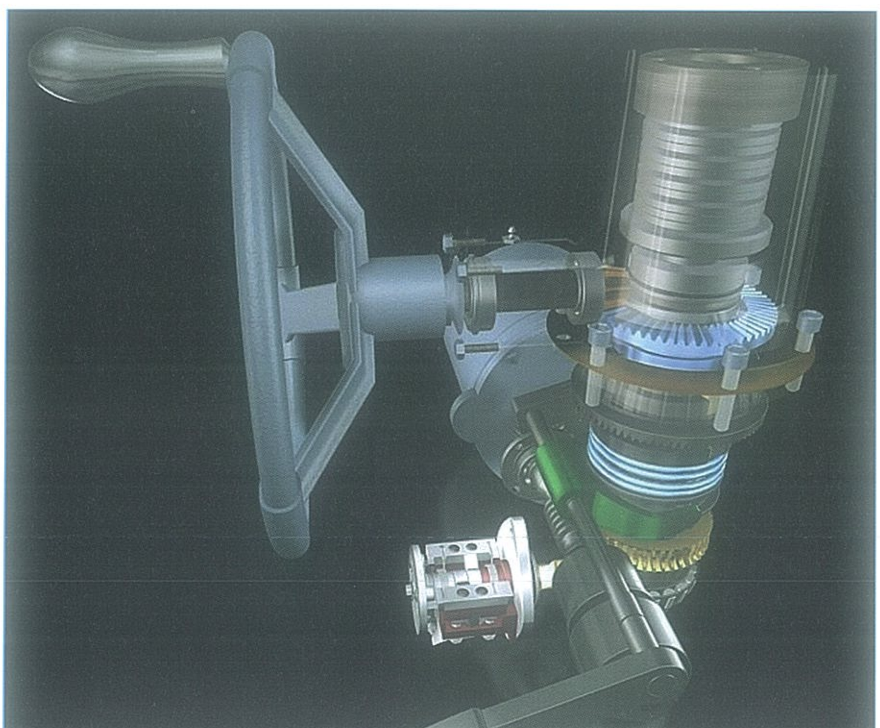

Figure 15. Virtual Animations to Explain Equipment Operation.

Francisco GONZALEZ AÑEZ has a degree in Industrial Engineering from Madrid's E.T.S.I.I. and a diploma in PSA from the IAEA. In 1983, he began working in the nuclear safety department of Empresarios Agrupados, and in 1986 carried on in the same area in CIEMAT in projects related to PSA methodology developments: Human Reliability and Common Cause. He joined TECNATOM, S.A. in 1988, where he worked in the area of operating experience processing and was Project Director of nuclear power plant database management and maintenance. In 1998, he switched to the area of training as project director of training development and plans for Spanish nuclear power plant maintenance personnel. Since early 2003, he is head of TECNATOM's Maintenance Training Center.

Tomas BATUECAS graduated in Physical Sciences from Madrid's Universidad Autónoma in 1982 and earned a Master's in Nuclear Engineering from the CIEMAT in 1983. He has worked in TECNATOM since 1986, where he is currently Project Director in the New Technologies Unit. His work has primarily focused on the area of real-time simulation and on information and communication technologies applied to training.

Ricardo SALVE began his professional career in Empresarios Agrupados as a mechanical design engineer. He then joined UNESA and, from CIEMAT, took part in project LOFT. He subsequently took part in managing the PIE nuclear R&D plan as secretary of the UNESA research group and directed several international projects (PHEBUS, LACE, LACE-E and ACE). In DIN, as R&D director, he promoted several projects related to Virtual Reality and was a member of the PIE Application Committee. He is currently Sectorial Project director in TECNATOM.

Enrique RODRIGUEZ MARTIN has a degree in industrial technical engineering from Madrid's Polytechnic University. He joined TECNATOM in 1994 as head of the damper maintenance workshop. Qualified as Level II in visual inspection techniques and functional damper testing, he took part in support inspections and functional damper testing in electric power plants. In 2000, he joined the Maintenance Training group of the Training Division, where he currently works as a specialized instructor in the mechanical area.