Deployment Scenarios of DVEs in Education

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Abstract: DVEs, along with the Internet in general, offer a number of attractive features for the education sector. However deployment in traditional educational environments, such as secondary schools, has not been achieved on a noticeable scale so far. In this contribution, we discuss technical and pedagogical issues, and specifically define possible scenarios of how this technology can be introduced to the school sector in a sustainable way.

Introduction

An accelerating factor in the use of the Information and Communication Technologies (ICT) is the recent advances in the fields of multimedia and telematics applications. Multimedia and telematics comprise the hard core of ICT. Multimedia can be considered as the combination of any two or more different media types (text, graphics, images, audio, and video). Furthermore, hypertext and hypermedia technology uses hyperlinks in order to represent in a structured way information that could be in various media types. This technology gives the user the ability to explore the information in a non-linear format that changes dynamically according to the user's choices. Additionally, virtual reality applications offer 3D interactive environments that can simulate real-life events and have great potential for educational purposes.

On the pedagogical side, new learning methods arise from the use of multimedia and telematics applications. These methods focus on the learner and allow an active, creative construction of his/her knowledge. New pedagogical models exploiting the potential of these technologies are emerging and new information or knowledge sources are now at the learner's fingertips. Informal access to knowledge through museums, science centres, libraries or browsing on the Internet is playing an increasing role in the learning process, but its impact is far from being understood. On the content side, the subject matters as the learning goals themselves are rapidly changing. On the software side, software agent technology enhances learning by providing intelligent assistance to learners in situations where direct manipulation interfaces are insufficient. Virtual reality techniques reduce the cognitive load in the use of some applications and thereby improve learning efficiency. Knowledge modelling has the potential to improve capitalisation of knowledge, while at the same time offering the learner or the professional the opportunity to reflect upon his/her knowledge and develop learning skills.

Today, most countries consider multimedia and telematics technologies as an educational tool and are trying to incorporate them actively in their curricula. The main concept is that the use of these technologies can significantly contribute to the educational process, supporting in parallel the role of the teacher. For example, by participating in scientific experiments conducted jointly with students in other schools and by drawing their information from various sources on the network, students learn critical information-age skills and build higher-order thinking skills. Furthermore, they learn to use electronic tools to access information and develop research skills using the technologies they will face in the future.

Furthermore, many pedagogues have stated that multimedia and telematics applications could improve the quality of the offered education, because they can simulate many basic models of the learning process and the natural proceeding in which man assimilates knowledge. In particular, telematics technologies can simulate the learning by exploring and the incidental learning, while they could be used for the immediate access of learning materials and the collaboration among students.

Distributed Virtual Environments

A simple definition of a Virtual Environment (VE) is a computer-generated simulation, and the term usually implies the use of 3D computer graphics in the interface. VEs can in addition be multi-user, supporting multiple interacting users, and distributed, running on several computers connected by a network. It has become common to refer to a VE with both these additional properties as a DVE (Distributed Virtual Environment). A Distributed Virtual Environment (DVE) allows a group of geographically separated users to interact in real time. The environment in which a DVE user is immersed is three-dimensional to the eye and ear. Moving in the environment changes the user's visual and auditory perspective. Unlike a video conferencing system (where an attendee's screen shows other attendees in their own video-conferencing rooms), DVE users assemble in a virtual world - they are all seen, for example, seated together around a conference table in one room, or walking together in a virtual building. Every user of a DVE appears in the computer environment as an avatar - either a customised graphical representation, a video of the user, or some combination of both -, which he or she controls. The user, besides interacting with one another, also deals with one or more computer simulations. While in use, a DVE can change continually, in every aspect. Further, a DVE can grow dynamically by accepting contributions of objects and structures from many sources. On one hand, interactivity is a basic requirement of all virtual environments. On the other hand, distributed virtual worlds require a certain level of persistence to achieve the impression of a single shared world. Persistence is realised by distributing and synchronising user input as well as user independent behaviour.

Virtual environments provide a way to combine the best features of real-world information navigation - memory of places and visual cues - with the best features of online navigation - fast searches and sorting and quick cross-referencing. By being able to manipulate data the same way we manipulate objects and ideas in real life, we can spend more time creating and understanding things and less time figuring out how to operate them. A well-designed environment can help us experience things in a larger context and pick out useful information from complex systems. Environments that mirror the physical world can show us exactly what is going on and keep us informed. Such DVEs could be used as collaboration and training tools. One can integrate interactive learning objects into a DVE and have people learn in that environment by doing and communicating with others. Furthermore, it is possible to provide educational material in many different media formats through a virtual world, giving to the users a unique experience. One advantage of VEs could also be to provide remote access to expensive and/or specialised laboratory hardware.

The role of DVEs in education

Implementations of DVEs, along with the Internet in general, offer a number of attractive features for the education sector:

- They may have cross-platform compatibility.
- Software for creating DVEs content can be downloaded for free.
- As some DVEs sit upon the World Wide Web, existing student knowledge is applicable, easing use.
- Pupils are used to DVEs from popular games, and expect immersion from innovative computer applications.

DVEs in education can be used in various ways but the most promising ones are either as mediums for education and research or as collaborative mediums.

As a medium for education & research

DVEs are being proposed as a means to facilitate both teaching and research in the educational sector. Indeed this is the most obvious role for DVEs. Three-dimensional content can be created and distributed to one's own students, or made more widely available to learners across the globe. There are plenty of obvious applications for educational simulators in a number of fields: physics, planetary exploration, archaeology, biology, and chemistry all can benefit greatly from better visualisation technologies. The point of these systems is not necessarily the amount of things that can be done with them but the fact that students can have the power to create them on their own and can find it fun and motivating to do so. Any textbook or course materials that have

3-D graphics, such as architecture and engineering, may benefit from DVEs. If the course materials, or the research papers, require multiple drawing of a 3D object or space, then clearly DVEs will give benefits.

More abstract representation -that is data visualisation- is also increasingly supported. Data visualisation can be easily supported in that the objects can use an anchor node to point to textual, tabular material describing the data in other forms. This ability will extend the range of subjects that benefit from DVEs to include those that not only deal with spatial objects but also call upon quantitative data that can be spatially represented, such as the social sciences.

As a collaborative medium

One of the longer-term opportunities, but possibly the most exciting, lies in the educational use of the shared spaces for distance teaching and project collaboration. The communicative worlds, similar to those described above, would allow for students and stuff to engage in distributed meetings, seminars and tutorials. A number of trials using these existing technologies are being tried.

Increasingly the Universities seek to adapt, supporting learning-for-life, in addition to more conventional students. Such technologies may mitigate some of the problems of isolation that distance learning brings. The students not only access course materials, but also meet in social spaces to discuss them with stuff and fellow students.

Collaborative virtual environments provide gathering grounds for new communities and types of interactions, and they give people a voice like they have never had before. We can share experiences and visions and learn to understand the other person's point of view. We can attend concerts, act in plays, and attend classes with an international audience. As long as people have something to say to somebody else, they can say it online.

Virtual European School

VES is a European project in the Educational Multimedia Sector, aiming to build up a comprehensive resource on teaching and learning material for secondary schools (pupils 10-19). The offer of the final VES system (ready in February 2000) will contain multimedia material, CBT products, and also additional background materials, such as passages from schoolbooks, or Internet resources. A major strength of VES is that a large consortium of educational publishers supports it. Over 20 publishers from 4 countries participate in VES providing content and designing the system in such a way, that VES fits into the working process of publishing houses. Therefore a smooth work-flow for delivery of material is guaranteed, and VES has the potential to become in short time one of the primary providers of on-line material in the major participating countries, that is Austria, Italy and Greece. However, in order to become a successful system, VES not only needs to fit the needs of publishers, but also the needs of its end-users, that is pupils and teachers in their role as multipliers. In order to integrate schools in the design process, VES has established a continuous feedback process in each of the three VES countries. In each country a regional school-network is collaborating with VES. Ideas are brought to the schools for evaluation and feedback is integrated into the design process. VES will be turned into a commercial system in the beginning of 2000. Billing and Copyright issues need to be implemented in a sustainable way. These topics will be essential for the success of the exploitation strategy of VES.

Deployment scenarios of DVEs within VES

Pedagogical issues

Using innovative technologies, VES aims to support new ways of learning. Providing students an access to the whole base of learning material gives them the opportunity to become more autonomous in their learning process. Students will no longer rely on only one source of information, but will be able to compare different sources and find additional information on their subject.

A typical example could be a DVE discussion platform on the various parliamentary systems in Europe. The DVE environment could provide the data, but the pupils can discuss on which voting or representation rules seem the most effective and democratic ones. For younger pupils a DVE on different climates throughout Europe would be more appropriate. A teacher can be present in such an environment, monitoring the cross-national discussions, and intervening only on specific open questions.

The key feature in these applications is immersion. DVEs can give a three-dimensional realistic view of an environment or situation. Therefore navigating within a DVE, learning is an active, explorative process. Views of the environment are individual, since persons are located in different positions in the environment

However, immersion opens the road to new forms of electronic communication. As described in the example above, students are enabled to explore the DVEs together. Therefore they can exchange views on topics represented in the DVE and cross-national teamwork can take place. These communication processes are essential to DVEs.

An even stronger form of communication, which will be enabled in VES, is transnational role-play. These forms of learning are ideally fitted for virtual environments. Through avatars, pupils can take specific roles in discussions, and learn to take points of views, which they naturally would not be inclined to. It is known that role-plays can open up prejudices of learners and also help them to overcome personal fears and inhibitions.

Scenarios of usage

Using DVEs in education encounters several obstacles. First and most important the limited bandwidth with which most schools are connected to the information infrastructure. However also more soft facts, as the missing of VR content, and the very limited experience of teachers with this sort of technology, need to be taken in account, when one designs a learning platform based on DVEs.

Within VES this problem was tackled, by defining several strategies, how to introduce DVEs to the target groups. More specifically there are three main scenarios envisaged:

- DVEs as Web site entry and navigation tool: A DVE used as main VES user interface, which leads, through objects allocated into that world, to other VES functionalities, such as search, compose or retrieve content. These functionalities in a first development step can be traditional functions (chat, newsgroup, search, etc.).
- DVEs as learning units: VES will contain many individual learning units from different content providers. Some of those learning units could be DVEs, as fixed virtual worlds where objects in those worlds could be linked to specific content objects (such as texts, videos, and simulations). Further of course in such environments VR objects are envisaged. Participants can interact with objects, and gain access to the relevant learning units.
- DVEs as general content user interface: As a third development step, it is planned to provide a DVE tool set to teachers, containing several model worlds and a database of 3D objects to be allocated into these worlds by the teachers.

In sequel we present these scenarios in more detail.

DVEs as Web site entry and navigation tool

The Virtual Learning Centre represents an attempt to build a learning environment combining real life situations, educational principles, virtual reality features and WWW technology features. The development scenario foresees, that in a first stage the Centre, will be merely an entry point to traditional functionalities, such as search, browse content etc. in a two dimensional interface.

However the aim is to evolve this entry point to a fully functional Virtual Learning Centre. Within this Centre the participant will have access through familiar objects to typical functions. One example abstraction that we use for representing the stored material of the VES system is a building of an exhibition centre, where publishers have their own place to display their educational products. The centre is organised in halls, or thematic units. Each hall is organised around a learning subject, like natural sciences, art and culture, technology, foreign languages and others. Furthermore, each hall that represents a specific subject is divided in rooms, where each room represents a different learning age.

Every room of the centre offers different material, but the structure of the room is the same for all. In every room, there are kiosks that represent the publishers that put material in the VES system. Every publisher has its own kiosk in every room, where it displays the material that belongs to him. In the kiosks there are entities that represent the content material of that publisher. For example, a user can go to a kiosk, select a book, open it, see the metadata information about it that is stored in the database of the VES system and if he is interested in this item then he can view or download the relative content unit. There is physical representation of the most recently added items in the database, while the older items are inserted in a list, which the user can browse and select to view any of these. In this way there is no need to have physical representation for every content unit that is stored.

Having this hierarchical structure, the DVE environment becomes very easy for the user to navigate in it and find the material that he wants. In addition, the user can get used to the virtual environment after some visits and not get lost in it. Every room of the centre is a separate small file of a virtual world, reducing thus downloads times, and the user can go from one room to another through appropriate portals.

The Virtual Learning Centre comprises a number of other spaces characterised by function. There is an information centre where the user can get available information about the environment, the rooms and how to get there, latest news and others. Furthermore, there exist a conference room where predefined lectures, presentations, seminars and other events take place. As the VES system expands there will be and other rooms with specific functionality.

In every virtual world that represent a room, the user has the ability to interact with the world through appropriate buttons that are positioned in a different frame in the browser window. Thus, there is a function that gives the user the ability to see in a plan view where is located every time and find his way to other rooms. Also, the user can switch viewpoints, take predefined paths, or view certain simulations of specific tasks in the world. At every time, the user can obtain help about the environment and how to use it.

DVEs as learning units

DVEs are not at all common in the educational sector, and especially educational publishers have hardly any experience in this field. Building a comprehensive resource on learning material, based on VR techniques, is currently not feasible. ´

In the case of content production, it is possible to circumvent this problem by starting to develop single DVE content units, where a clear educational added value can be seen, and where content providers (in the case of VES publishers) are sustained by VR specialists in the creation of such worlds.

In the VES context these worlds are planned to be non-populated, but rather targeted at immersion properties of DVEs. An example could be the simulation of sewage treatment plant, where all the work cycles are shown, and the reaction of the system is simulated when different mechanism are being used. Limiting the DVEs to this scope not only facilitates the production and technical issues, but also gives a controllable way for teachers not used to this technology to adopt virtual environments in classroom teaching.

Within VES this development step is certainly not seen as an end-point, but rather as a first step towards deployment in school use. Once teachers, as multipliers get acquainted with this novel form of content, more interactive and open environments will be inserted.

DVEs made from collections of building blocks

The most advanced scenario, in terms of user integration is the one of DVEs as general content user interface. In this case it is envisaged that all content is allocated into virtual worlds. The working scheme would foresee that publishers and VR experts create an abundant database of basic DVEs and base objects, which can populate the environments.

An example of such a unit could be a VR timeline. The time-line indicating the years (or centuries) would present the basic DVE, while the base objects would be for example figures (e.g. an image of Napoleon), scenes and movies (a short video on life-style during French revolution period), but also more basic objects as dictionaries, notice boards, etc. Teachers would then take the empty world and populate it with the objects suiting their needs, associating to the base objects functions defined by them.

A user analysis performed within the project VES has shown that this deployment of DVEs is currently not sustainable in most educational settings. Therefore it is necessary to start out with the less advanced scenarios, in order to acquaint teachers to the new technology.

Design Issues

The design of a Virtual Learning Environment can be based on the idea of an exhibition centre, where the educational material is organised hierarchically according to a universal or subject-specific classification scheme for educational content. The exhibition centre is organised in “thematic halls”; each of them organised around a learning subject, such as mathematics, science, geography, art and culture, foreign languages, etc. Each “thematic hall” representing a specific learning subject is further divided into rooms representing the subdivisions of each subject according to the classification scheme. Moreover, at the bottom level of the hierarchy there exist rooms representing educational content for different learning ages.

In order to have a user-friendly, integrated, and interactive user interface, the 3D environment of the Virtual Learning Environment can be combined with several HTML frames, each of them having its own functionality. Thus, one frame is used for embedding the Virtual Learning Environment, another is used for displaying status messages to the user and the rest display a console of buttons for interaction with the Virtual World. For example, there always exists a plan view representing the current user’s position at the Virtual Learning Environment and facilitating the navigation through different rooms. Also, the user can switch viewpoints, take predefined paths, or view certain simulations of specific tasks in the world. Finally, the content units that the user selects to view are displayed in a separate window so that the main console is always visible, avoiding in this way continuous back and forward actions.

Implementation Issues

An approach is to use VRML for the implementation of the Virtual Learning Environment. VRML is an acronym for the Virtual Reality Modelling Language. The aim of VRML is to bring to the Internet the advantages of 3D spaces, known as VRML worlds whether they comprise environments or single objects. The ISO/IEC 14772-1 international standard specifies the current version VRML 97. VRML offers a number of attractive features for presenting educational material including ease of use and cross-platform compatibility. VRML defines most of the commonly used semantics found in today's 3D applications such as hierarchical transformations, light sources, viewpoints, geometry, animation, fog, material properties, and texture mapping. A VRML world is written as an ASCII file, which is interpreted by a VRML-compliant browser and converted into a 3D display of the described environment.

Another approach for the implementation of the Virtual Learning Environment is to use Superscape’s VRT, which is an application for creating 3D environments. The file format of VRT worlds is SVR, which is a compressed binary file that contains all the geometry, textures, sounds and behaviours needed for the interactive 3D world, in a highly compact and encoded form, giving short download times and rapid set-up times. The 3D browser that displays VRT worlds is called Viscape and it is freely available. VRT has also a purpose-built behavioural control language, called Superscape Control Language (SCL) which is based on the C language. SCL is a compiled language and each program consists of a list of commands that are executed in every frame. SCL can be used for writing programs that create links to other pages and add intelligence, animation and other specific behaviour to objects. Furthermore, SCL provides read and write access to documents stored on a Web server through HTTP.

In order to add the capability of, more than one, users accessing the same Virtual Environment at the same time and to create a Distributed Virtual Environment (DVE), a communication platform is needed for performing the interaction between the different users across the network. A DVE provides the users with access to a shared 3D environment. All participants are presented with the illusion of being located in the same place, such as in the same room, building, or terrain. That shared environment represents a common location within which other interactions can take place. The shared environment presents the same characteristics to all the participants. For example, all the participants could get the same sense of the temperature and weather, as well as the acoustics. Additionally, DVEs provides some way of communication between the participants by means of typed text, voice, etc. A DVE system consists of four basic components that work together to provide the sense of immersion among users at different sites. These are a graphic display, communication and control devices, a processing system, and a data network.

The main commercial platform for implementing DVEs from a VRML or a SVR world is the Blaxxun Community Server. The Blaxxun Community Server is a multi-user server that supports the operation, administration and usage tracking of virtual worlds that many users can inhabit simultaneously. It is an open system that supports all the relevant standards: HTML, VRML, Java, vCard, ActiveX, OCX, Direct3D and OpenGL to enable 3D multi-user interaction and it works together with the Blaxxun Community Clients.

The implementation of a DVE from a VRML or a SVR Virtual World can be accomplished by setting-up the Blaxxun Community Server, configure the Virtual World as a DVE using the appropriate set of parameters, and tuning the system by carefully adjusting the values of certain parameters.

Conclusions

The construction of Distributed Virtual Environments should be seen as a design problem in the broadest sense. VR projects with an educational remit should recall at all times the criteria of educational effectiveness. The drawbacks as well as the advantages of various aspects should be evaluated, including the effects of concretising information, of appropriateness of spatial metaphors and of the interface. Regarding shared worlds, they should be investigated to support distance tutoring and research, but with caution to ensure that the social grouping effect of actual meeting is not lost.

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