new technologies for higher **education**

Proceedings of TMR Euroconference
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1999

Technical Information

FOREWORD

 The 1998 Euroconference on New Technologies for Higher Education, the first of a series of two events which took place at Universidade de Aveiro, Portugal, from 16th to 19th September, addressed the recent developments in the area of new educational media, both from the technological and educational points of view. Distance learning and the use of multimedia are already having a significant impact on the way university teaching is done, and with the rapid pace at which the underlying supporting technologies are evolving and the communications and computing infrastuctures are developing, their impact is certain to grow in the near future. This trend will also change the organizational framework in which university education will be carried out. For this changes to fully materialize however a very significant effort is necessary. This has been recognized quite early by the European Union which in 1988 started the DELTA programme and more recently, within the European Fourth Framework Program, with TELEMATICS for Education and Training and the creation of the Educational Multimedia Task Force, as well as by a number of countries that financed their own national R&D programs. Research in the area is quite active, with a significant number of good research groups spread throughout Europe. New and innovative tools and applications are being generated at a fast rate, innovative pedagogical experiences are taking place, making it particularly important for researchers entering the field to keep abreast of the latest developments.

 The wide range of new opportunities created by the ever increasing availability of innovative tools and applications presents several important challenges to educationalists (teachers, courseware developers, educational planners and managers, etc). One of the major challenges still requiring considerable effort is the need for increasing user acceptability and uptake relative to the new technologies. The issues of userfriendliness, cost, building up institutional frameworks suppportive of the new educational technologies, are now factors of paramount importance for their dissemination. Appropriate user training and awareness of the benefits brought by those technologies are other decisive factors for success that must be addressed both from the point of view of the software providers and of the open and distance learning experts.

 The effective use of the new technologies requires that people from diverse backgrounds be put into contact and work together: engineers that make the communications infrastructure to advance and the capabilities of computing and multimedia devices to progress, computer scientists that provide software frameworks integrating the new capabilities into a friendly and productive working environment, educationalists and cognitive psychologists to reflect on the impact of the new media on teaching and learning. Hence the interdisciplinary nature of the event that aimed at attracting people with these different backgrounds.

 Euroconferences are one of the Acompanying Measures of the Training and Mobility of Researchers (TMR) programme. They are defined as *"high-level scientific meetings ... bringing together young researchers and established scientists"* [TMR Information Package].

 In conformance with the Euroconference definition, the program has been designed to expose a group of young researchers to some of the most relevant research being done in the area, through invited lectures from senior researchers that have made significant contributions to the field. It also offered the young researchers participating the opportunity to give an account of their work-in-progress through communications and

poster presentations, to get the reactions to what they have already achieved, to get advice on the best ways to pursue their research, and to establish relations and links that will be useful for the progress of their research.

The program included into four main themes:

- Multimedia/Hypermedia Development tools
- Cognitive Processes and Pedagogical Experiences
- Open and Distance Learning and Cooperative Work
- Impact of the Information Technologies in Higher Education

In each of these areas a number of invited papers provides an overview of the state-of-the-art, whereas the communications describe current research-in-progress.

The event drew a good response from the research community, with a sizeable attendance and a significant number of presentations by young researchers. The invited papers offer an interesting overview of the main issues being tackled by the research community, with invited speakers coming not only from within Europe but also from the USA, with a mix of technological and educational backgrounds. The communications and posters have shown innovative work that demonstrates potential to lead to significant changes in the pedagogics and the organization of higher education in the years to come.

António B. Ferrari
August 1999

neuvec-nfr. rene 98
new technologies for higher
education

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TABLE OF CONTENTS

eurocit-it.-nvr. 98
new technologies for higher
education

univers.dfr.s.inz. 98
new technologies for higher
education

A. Impact of the Information Technologies in Higher Education

Invited Papers:

C. Fowler, "*Going Virtual - Will IT help?*"

A. Derycke, "*Designing the virtual campus: some issues, technologies and methodologies*"

P. Veiga, "*RCTS: The Portuguese Network for Education, Science and Tecnology*"

P. Wintlev-Jensen, "*Overview of existing and future EC supported research avenues for technology enabled education and training*"

Communications:

N. Mogey, "*Supporting successful implementations of learning technology*"

L. M. B. Gouveia, "*A technological related discussion on the potencial of change in education, learning and training*"

The four invited papers address different aspects of the theme. Chris Fowler's "*Going Virtual - Will IT help?*", addresses some of the non-technological issues behind the concept of "Virtual University", drawing attention to the importance of the social aspects of learning and the need to manage changes in educational agents and institutions. Alain Derycke's "*Designing the virtual campus: some issues, technologies and methodologies*", describes the work done by his group at Universite de Lille (France) in establishing the first generation of a Virtual Campus System (VCS). The experience gained led to the belief that a "shift in paradigm" is necessary in the next generation VCS. The new paradigm being proposed has obvious affinity with issues raised in the previous paper, with its emphasis on the importance of the social environment for effective learning.

Pedro Veiga´s paper, "*RCTS: The Portuguese Network for Education, Science and Tecnology*", provides an overview of the current state of the Portuguese network infrastructureand its planned evolution. Of the talk of the final invited speaker, P. Wintlev-Jensen of DG XIII, "*Overview of existing and future EC supported research avenues for technology enabled education and training*", only the abstract is included.

Two communications dealing with the impact of the Information Technologies in Higher Education were presented. Nora Mogey's, "*Supporting successful implementations of learning technology*" reflects on the experience of LDTI (Learning Technology Dissemination Iniative), a scheme of the Scotish Higher Education Funding Council started in 1994. "*A technological related discussion on the potencial of change in education, learning and training*", by Luis Gouveia details a proposal of a roadmap to transform his own institution, a Portuguese private university, into a "virtual university".

1. GOING VIRTUAL – WILL IT HELP?
INVITED PAPER

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1.1. INTRODUCTION

We, at BT Labs, have been working on new learning environments and technologies for over three years, and this paper represent some of our current thinking. It sets out to briefly state why we need virtual universities, some thoughts on some structural changes required to move to a virtual platform, and a description of some of the technology we have applied in going virtual. Finally a few conclusions are drawn from our experiences.

1.2. WHY GO VIRTUAL?

There are many reasons why so many universities are actively exploring the possibility of offering virtual courses. At the risk of over simplifying the situation, I would say that there have been at least two gross pressures for change – increasing demand; and decreasing resources. I would also argue these are universal pressures and are certainly common to Europe if not to the world at large.

Increasing demand has resulted from an increased expectation that more young people should receive a higher education. Higher Education (HE) is no longer seen as

being for an elite only and therefore only meeting the needs of a small percentage of population. In the UK, for example, between 1989 and 1992 the number of full-time HE students increased by 28%. In 1979 only 24% of 17 and 18 years old went on to a degree course. By 1992 this number had risen to 54% (see Mackinnon et al, 1995).

This expectation has been fuelled by Governments recognising that the prosperity of their country is increasing dependent on intellectual rather than physical capital. The onset of the "Knowledge Economy" (see Stevens, 1996) with its emphasis on timely and pertinent knowledge to sustain the economy has resulted in the need for continuing education, to update or even re-skill the workforce. Lifelong learning, therefore, provides another source of demand on our existing Higher Education institutions.

Interestedly in 1992, one of the richest European countries, Switzerland had one of the lowest percentages of 18 – 29 year olds at university (5.4%). In contrast Spain, which has a Gross Domestic Product of less than a third of Switzerland ($37k versus $12k per capita), has the highest percentage of 18-29 at University (14.3%). Spain in many ways represents a changing and growing economy compared to the more traditional and stable Swiss economy (see Mackinnon et al, 1997). Of course care must be taken in interpreting such figures as provision of non-university based HE and definition of terms will differ

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2 Also Director at the Centre for Future Learning, Institute of Education, University of London.

across Europe, and the effects of more educated workforce may take time to work through the economy.

Another indicator of increased demand for life long learning could lie in the number of part-time HE students. As demand for life long learning increases one might expect the number of part-time students to increase as students 'drop in and out' of courses. With this in mind, it is interesting to note that in the UK between 1989 and 1992 the number of part-time HE students increased by 55% (see Mackinnon et al, 1995). However, I would expect the increase in life long learning not only to effect the mode of learning (i.e. part-time or full time), but also the nature of the courses (less degrees and more shorter sub or part degree qualifications that can either be stand alone or accumulate flexibly over time). More flexibility may also reflect less dependence on the physical entity of the university. Students indulging in lifelong learning may wish to undertake courses from home, work or the college.

Unfortunately this increase in demand has occurred against a backcloth of at best stable and at worst decreasing levels of resources. In the UK in particular the HE infrastructure is creaking under the weight of increasing student numbers, and there are fears that the quality of teaching is suffering . One answer is to improve efficiency (whilst retaining effectiveness) and technology has certainly been viewed as a possible mechanism to improve efficiencies (see Dearing, 1997). At least two models are advocated – increase outreach and replace teachers.

'Increase outreach' uses technology to provide greater access to teachers via the technology. An obvious example would be the use of video-conferencing to 'pipe' lectures to multiple sites. The proposition is attractive. The lecturer, at least at first sight,

need not change his or her practice, and many more students, albeit at a distance, have the opportunity of seeing and hearing the lecture as if they were there. Of course this assumes that 'lectures' even when live are an effective way of teaching (they are certainly very efficient!), and that video-conferencing is equivalent of 'being there'. Many of the issues of using technology to mediate between the teacher and learner will be revisited in Section 4 below.

Another facet of 'increased outreach' can be understood from the increasing pressures for institutions to be become more commercial. More students equals more money – more money and less costs equals more profit, and profit ensures the existence of the Institution. If the technology can be used to satisfy the national market then why can it not also be used to extend the market reach. Distance learning should not be bounded by geography, so the technology can now be used to reach students all over the world and Education becomes a global market. It is not my intention to explore this option in this paper, other than to say Globalisation of Education is a complex and difficult process, that technology alone cannot fully address (see Lenn & Campos, 1997).

If there is a shortage of teachers, then rather than hiring expensive people we can replace them with new technology. This certainly appears to be the goal of some of the more AI orientated research into teaching machines. Embedding user models of teachers and learners into learning system has proved to be challenging, and part of the challenge may be that teaching and learning is a social as well as cognitive process. The importance of the social aspects of teaching and learning makes replacing teachers with technology a less attractive proposal. However, technology can supplement and assist teachers and learners. Computers are

univers-ity conf. 98
new technologies for higher
education

powerful tools that in the right hands could result in improved learning efficiencies and effectiveness. However the role of the teacher may need to change from being the 'sage on the stage' to the 'guide on the side'. Again we explore some of these management of change issues in later sections.

There are many more reasons for Universities to consider going virtual. An obvious one is that we now have the technology to deliver a virtual course. This may be true, however, understanding how we apply that technology is probably still not so well understood. The issue of valid application is explored in Section 4 and some examples of how the technologies have been applied can be found in Section 5 below.

1.3. WHAT IS A VIRTUAL UNIVERSITY?

My intention in this section is not to define a virtual University - others have already more than adequately defined it (refs). However, Universities do have certain characteristics that a virtual version should retain, and equally there are characteristics that are unique to the virtual university. It is these defining characteristics which I intend to identify and discuss in the section.

A very simple but important characteristic of a 'real' university is location. Most real universities have a physical location. Some universities can be found on a single site or campus whilst others may be dispersed. Even in the most extreme dispersed situation, students generally feel a sense of belonging. On this physical site, the lecturers produce and deliver their teaching. The UK's Open University, which is in part a virtual university, still has a single site at Milton Keynes where the teaching materials are produced, but they can now be consumed by students at multiple locations all over the UK. In a true virtual university the

production could also be undertaken at multiple sites. A student could enrol in a virtual university but actually undertake a course developed and possibly delivered by quite a different university. As a student, I may wish to take the best course on subject X in the world, but I also want to choose to do it in my own time, at my own speed, and at my choice of place. The virtual university must be able to meet these needs.

To support the 'any time, any place, any course' attribute of a virtual university requires at least two further characteristics. First there is a need for some kind of brokerage architecture that will allow the buying, selling and appropriate distribution of courseware. At the simplest level a broker helps assess, select and deliver appropriate courses for an individual according to their particular requirements (see fig. 1, next page). In a virtual university, I would argue that the broker must also accredit the courses. They will be responsible for putting together a package, that has creditability and meets the criteria for a particular HE award level (i.e. certificate, diploma, degree etc.).

The other characteristic arises from the personal nature of virtual education. Each individual is likely to have different requirements and some form of Learning Contract needs to be agreed between the Learner and the Broker. In this contract the level, mode and timing of the learning will be recorded. The contract will also record progress and could form an important component part of a Life-long Learning national database.

As well as the particular characteristic described above, a virtual university will need to inherit many of the features of existing universities. These include such features as access to Educational Resources, Support, as well as normal course and institution administration.

EdTech/online/conf. 98
new technologies for higher
education
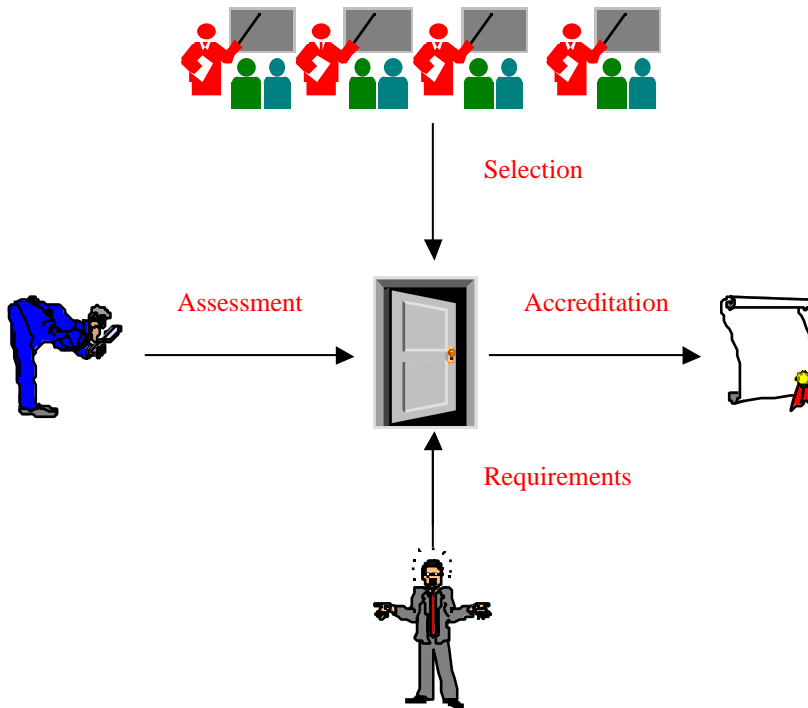
Figure 1: The four main Educational Functions of the Broker

Fig. 2 (following pages) provides some idea of what a service description for a Virtual University might look like.

Imagine yourself as a prospective student looking for a course on History. On accessing the Home page of the Virtual University, you are asked whether you are currently registered for a course or a prospective student. If you are already registered then you enter your name and password and access your particular course directly. The prospective student is
 presented with a number of choices, that are dependent on their state of certainty about their suitability for a course (knowledge analysis), the suitability of different types of courses (course profile analysis), and finally the suitability of different institutions offering their chosen course (College Profile analysis). There is also a facility to assess a student's learning style to help choose appropriately structured courses or to select an appropriate course configuration.

Sometimes a prospective student will know exactly what course and where they want it accredited and they can directly access that course.

By using these decision aids or analysis engines, the broker (the black parts of fig 2 below) can help the student select an appropriate course. Once selected the student then registers for that course. The broker also tracks the student's progress, and such information is used for assessment as well as payment purposes (pay-as-you-learn). Most course modules will be timed and there is a need for a robust authentication mechanism to ensure that the student doing the course is registered and the registered person is submitting the work. One idea is that people may have unique search patterns and learning behaviours that effectively leave a cognitive 'fingerprint' on the work they do. The 'tracking' component could note any significant changes in learning behaviour and alert the appropriate authorities.
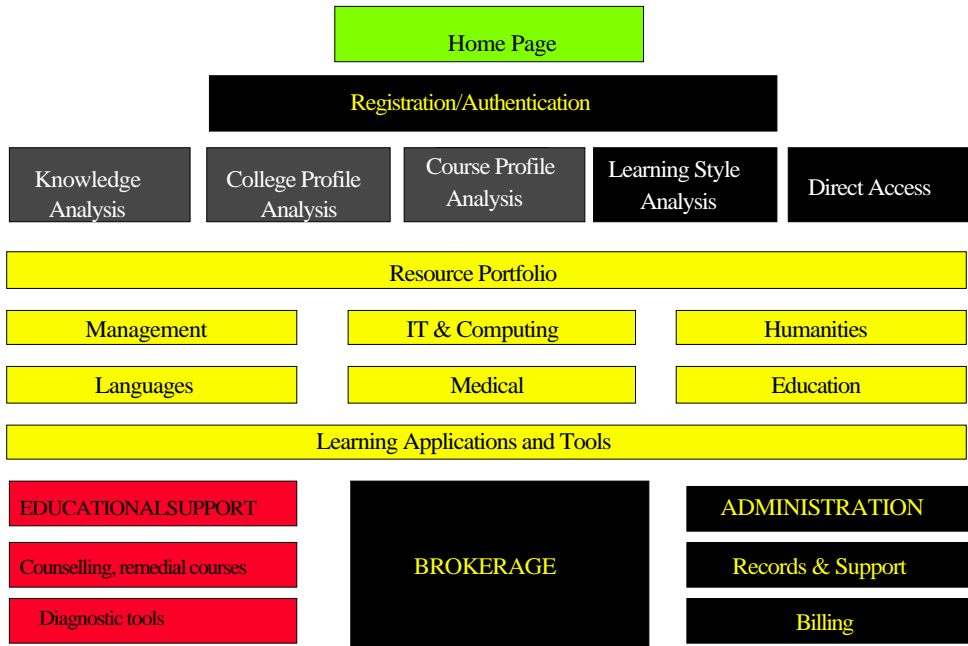
Figure 2: A possible service description for a Virtual University

1.4. WHAT ABOUT LEARNING

Clearly there is more to learning then just presenting content. The 'lectures-on-line' is not going to be sufficient for good learning. Further instructional designers need some model or framework of learning to help them make informed design decisions. Such a framework was developed by Mayes (1995) for BT, and its major components are described in figure 3:

The 'conceptualisation' stage is about presenting other people's concepts. The lecture or the textbook is a traditional way of delivering the content at this stage. In terms of new media, then the WEB is commonly used but, to date, it has failed to have the same fidelity or impact of the traditional methods. However, the new delivery methods have one significant advantage. They can be combined with various tools that can greatly enhance the student's interaction with the conceptual material. For example, there are annotation tools that will allow notes, in any media, to be attached to text, images or videos. Or summariser tools that will accurately precise text.

At the Construction stage the student takes the concept they have learnt and actively does something with it. In science, for example, this would be traditionally achieved through the Laboratory class, or in Philosophy the seminar, or Biology the field study and so on. The power of computers as modelling tools or simulators comes to the forefront at this stage, and yet they are very few examples, on the WEB at least, of virtual science laboratories, models or simulations. They are many more simulation examples available on CD-Rom, but construction should be viewed as a social process that involves co-operation between people and this is easier to achieve over the WEB.

A new Learning Framework

Delivery technologies....

Lectures,Text books TV, Radio, CDs	**Conceptualisation**	Audio Streaming Video Streaming HTML pages
Laboratories, seminars, field work, workshops,practicals	**Construction**	Java, Shockwave Remote sensors
Tutorials, informal chats,	**Dialogue**	Whiteboards Conferencing (audio, video, text)

Figure 3: Mayes' Conceptual Framework for Learning

The final stage is about dialogue. A powerful learning medium is other people. We learn a great deal through discussions and conversations with our peers and teachers. It is often the teacher and not the subject that inspires the student. In extending Mayes' framework, we suggest (Fowler & Mayes, 1997) that dialogue needs to be understood at all of the learning stages. At conceptualisation there will be dialogue for clarification ("what do you mean by…"); at the construction stage there will be dialogue of co-operation ("why don't we try….."); and at the dialogue stage you will find the dialogue of debate and argument.

Implicit in Mayes' framework is a shift in paradigm. The instructional paradigm with its emphasis on teaching rather than learning is no longer acceptable. The learner in Mayes scheme is empowered (constructivist or constructionist paradigm) but not as an individual but as part of a social group (social constructivist or co-constructionist paradigm). This shift in paradigm has important implications for teaching (see Mayes & Fowler, in press). The teachers in a virtual university have to change their role from being the 'font of all understanding' to being a facilitator who encourages and guides the student. Our own research at BT suggests that the major problems with the introduction of new technologies will not lie in the technologies themselves but in managing the change required by people and institutions.

1.5. APPLYING THE TECHNOLOGY - SOME EXAMPLES

What technology, and how and when its applied is a difficult area. Different people and institutions are at different levels in both their knowledge and their technology infrastructure. We need to understand the 'technology absorption' curve for introducing technology into HE (see figure 4 below).

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new technologies for higher
education
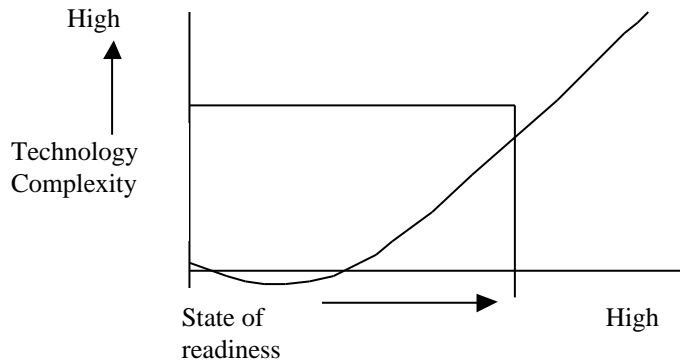
Figure.4: The absorption curve for technological change

What technology and how its introduced will depend on where an institution lies on the absorption curve. A key technology component is undoubtedly available bandwidth, which in itself also tends to correlate with types of available hardware and internet/intranet preference. The higher the available bandwidth the more likely you are to find high specification multi-media machines2 and the use of an intranet.

At BT labs we are collecting a number of

used to determine a change strategy for a particular organisation.

Below is a matrix using Mayes' learning stages and available bandwidth to help explain and the examples of different Education Technologies built for research purposes at BT Labs.

These exemplars are described in more detail in the sections below.

1.5.1. *CME – Continuing Medical Education exemplar.*

	High	Medium	Low
Conceptualisation			CME
Construction		VSL	
All Stages	ALE	RISE-NCN	RISE –HomeLearn RISE- Merlin

case studies of institutions which have introduced technology into their teaching. From these studies we hope to understand what are the antecedents or conditions that determine the 'state of readiness' of an institution to absorb a particular level of technology. If we can find behavioural indicators of this state (eg. levels of existing infrastructure, commitment of senior managers..), then such information could be

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2 The use of network computers could possibly replace the need in the future for sophisticate client machines.

CME was a prototype system built to compliment a conference – one of the traditional ways of delivering CME to Consultants and Doctors. It used relatively simple and available technology that could be accessed over 28kbs modem by a fairly standard PC. The software used was standard HTML in conjunction with real video and real audio. The real audio was synchronised with presenter's slides. However real video was not used to show presenters. It was argued that the most important thing for the audience is to clearly see the slides and hear the presenter.

Real video was only used for the conference's opening or welcome speech. This had no slides and is more social in nature and so seeing the speakers was deemed to be important.

The user of the system was given a number of presentation choices. They could either listen to the presentation and associated slides as already described. This choice also involved some limited text describing the slide and the use of a dictionary to explain any unfamiliar terms. Or they could view the slides with a fuller textual explanation and no audio (i.e. the 'slide show'). Finally the user could also choose to read the full text of the presentation (cf the conference proceedings).

The real video and audio data were all captured at the conference, and there were requirements on presenters to use 'powerpoint' for their presentations and to make their slide shows available. In this CME example it took relatively little effort and costs to set up a web site for non-attendees to get access to the conference material.

1.5.2. *RISE (NCN, Merlin and HomeLearn)*

RISE or Real Time Interactive Social Environments platform was seen as a generic learning platform. Generic in the sense it supported all stages of learning for all ages of learners (i.e. supporting Lifelong learning). RISE has two unique features. First it support WEB groups. When you log on to RISE, the system 'knows' who you are, what course you are on, and presents only material relevant to you. In other words it is both a personal and dynamic system. Secondly, RISE has a WEB based audio conferencing system built into it. From the WEB it is possible to set up an audio conference with upto 30 people using the Public Service Telephone Network (PSTN) or the ordinary telephone system. The use of audio conferencing was designed to support the informal social aspects as well as the

dialogue stage of learning (e.g. online tutorials).

Three educational instantiations of RISE were developed. RISE-Merlin, the first, was designed with the University of Hull to support teaching English as a Foreign Language (EFL) over the internet. BT provided RISE and Hull University supplied the required content. Students from all over the world were enrolled on a short trial. BT evaluated the usability of the system and Hull evaluated its pedagogical effectiveness. Overall the results were promising. There were some technical problems and these did discourage the less computer literate, but in general those students who persevered felt the system was equal to, if not better than, doing the face-to-face course

RISE-NCN took a different sector (Further Education) and a different qualification (National Vocation Qualification or NVQ). The system was used over an intranet although the interconnecting bandwidth was not that high (averaging around 128k). The Intranet was connecting 16 FE Colleges in the NE of England who had joined together in a telematics enterprise called the Northern Colleges Network or NCN. RISE was used to teach an NVQ in IT to college staff who were distributed across most of the sixteen colleges. RISE-NCN had all the same functionality as RISE-Merlin and in addition had a propriety groupware product (First Class) integrated into the system mainly to support the transfer of files between learners and tutors. In addition RISE was moved to a more robust technical platform using WEB Objects for its development. The trial was seen as primarily a technical trial of the system, and as such the new RISE platform proved to be more reliable and usable.

RISE-Homelearn, the most recent instantiation, was developed to support children's homework. It was also designed to involve the parents in supporting their children at home. The children were eight or nine years old. A small trial (eight homes only) was undertaken with support from

Apple Computers. During the trial parent's could access class teaching plans, email the teacher and look at the homework schedules. As part of the homework, two audio conferencing sessions were set up. One was with an author of a set book in English, and the other with a metreologists. The sessions were semi-structured involving work preparing questions and some homework following the audio conferencing session. The system was enormously popular with the children who both enjoyed using it and learnt much from it. It was less popular with the teacher as it involved him in considerable extra work on duplicating homework for the online group. In a fully implemented system involving all the children in the class this perceived extra work for the teacher would not be such a major issue. Parents initially were enthusiastic but over the trial their involvement declined significantly. Certainly the small sample size did not help encourage the mutual support that we were hoping to find amongst the parents.

As a generic learning platform, RISE has proved to be successful for schools, FE and HE sectors. Further information about RISE and its applications can be found in Mayes & Fowler (1997).

1.5.3. *ALE – Advanced Learning Environments*

ALE started with the assumption that high bandwidth (> 155mgB) to the desktop and high specification servers and clients would be a given in the near future. We then asked the question -'what would an educational system designed from Mayes' framework look like over a superfast network?'. We decided to use our own superfast network in BT Laboratories and content from our own M.Sc course in telecommunications. This course or parts of it could then be delivered to the learner's desktop through the ALE system.

At the conceptualisation stage, ALE allows groups of learners to access content in three different ways. First there was the possibility of 'dropping in' to a live lecture. A camera

and other equipment was placed in the back of the M.Sc lecture hall. Or it was possible to access a continuous stream of broadcast materials using IPTV technology. And finally, the student could select from a range of already 'canned' or prepared lectures.

These options were presented as three 'portals' or doorways in a virtual world. Representation of the learners (avatars) could meet or gather at the portal and communicate with each using real time text chat.

Currently we are developing the construction and dialogue stages for ALE. In construction we are looking at building a virtual environment in which the student has access to various 'construction' or design tools (e.g. whiteboards) and object libraries from which they can select objects in order to build their own simulations. In terms of dialogue we hope to build a specific area where people will actively go to engage in real-time debate. Real time debate we believe requires a real time high fidelity system that can make visible fine and subtle cues indicating levels of emotion, supporting the regulation of the conversations and immediacy of response. Its unlikely that real time text chat, for example, would meet these needs, and a high quality videoconferencing system is probably required.

1.5.4. *VSL – Virtual Science Laboratory*

The VSL was designed and built for BT by the Knowledge Media Institute (KMI) at the Open University, UK. Our brief to KMI was to build a collaborative online laboratory that could be used by primary school children. The collaboration should be possible over a distance. The experiment used was Hook's Law, and the children from varied locations were able to select different weights, see the effects of their selection on the extension of different springs, and plot their results. Although it was not designed originally to run over IP, it was later incorporated into RISE. This then allowed the children not only the real time object manipulation of

VSL but also the audio conferencing facility of RISE for better collaboration.

As a proof of concept the system was very successful. Further work is required to see if a library of scientific objects or instruments could be built, that allows teachers to easily build a range of different science simulations.

1.6. CONCLUSIONS

It became clear to us at BT Labs that there was a real risk of being 'seduced' by the latest technology. We needed a framework to rationalise our decision for the selection and integration of different technologies into an educationally valid system. Mayes framework has served as well, although the true test of it – the ALE demonstration – is still under construction.

The framework also helped to ensure that our prototype systems were pedagogically balanced between content, simulation and dialogue. Too many systems today are focusing only on content, which although important, is only one part of the learning process.

A further conclusiof was the importance of the social aspects of learning. Learning from people and with people seems important for effective learning. The 'loneliness of the distance learner' should not be under-rated and certainly distance learning systems to date have not always explicitly addressed this issue.

Finally, the introduction of new technologies is often associated with a 're-engineering' of a current process. Education is no exception and the required paradigm shifts demand significant changes in our teachers and institutions. Unless these management of change issues are understood and addressed, then it doesn't matter how good the technology is, it will, at some level or the other, fail.

To answer the question posed in the title – "Going Virtual – will IT help", the answer is " yes" as long as you remember to put the communication in the IT, manage the change, and design from a sound pedagogical framework.

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2. SOME ISSUES IN THE DESIGN OF THE VIRTUAL CAMPUS
INVITED PAPER

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Abstract-To support the new needs of potential learners in terms of flexible and distance education, we have placed ourselves in the framework of a constructivist perspective. In the context of continuing education of adults, we want to take into account the situated nature of the learning processes

Our aim with our project of a Virtual Campus System (VCS), is to support equally all the dimensions (time, place, population and cognitive and pedagogical dimension) of the flexible and distance learning problem space in an integrated framework centered on the learner activities.

Our major technical constraints were an easy access through a standard Web navigator and the support of the learner mobility and of a large range of CSCL activities.

To do so, our system integrates existing tools and provides the glue to transform these tools into more cooperative, and learning organization-aware tools. A particular emphasis has been put on the management, the work-flow, of the learning processes either individual or collective.

The Activity is the core of our design which gives a solid framework to support harmonious integration and the potential for long term and evolutive learning processes.

Our Virtual Campus is supported by a client/server 3-tiers architecture on the Internet.

From the design and experimentation of the Virtual Campus we draw some issues about the user interface and about the learning organization.

In conclusion, we explain why a shift of paradigm is necessary in the design of the next generation of Virtual Campus, defining new challenges for the designers of future VCS .

2.1. INTRODUCTION: TOWARDS FLEXIBLE AND DISTANCE LEARNING

Our assumptions about the development of flexible and distance learning, or distributed multimedia learning, are grounded by the fact that learning is not located in time and space and that there are no real "teachable moments". User's needs for their education, individually or collectively, have considerably changed, especially under the pressure of both organizations, enterprises and new ways of life. Potential learners require more flexibility, continuous support of their lifelong learning processes, reactivity in the introduction of new knowledge, real involvement or participation, and more active learning modes, favoring learning by discussing, doing, designing... We place ourselves in the framework of a constructivist perspective of flexible and distance learning [1], so much at the cognitive level of knowledge theories, so much at the social level of education and construction of knowledge. It means that we take into account seriously the contextual dimension, the situated nature of the learning processes [2] and the need for the learner to be a member of a community of practice, even if this community becomes virtual through the Virtual Campus. Finally, in the context of continuing education of adults, we want to support the articulation between the work situation and context and the learning situation and context, whatever these situations are individual or collective in the

framework of the teams, the groups, or in the whole "learning organization" [3].

2.2. THE VIRTUALIZATION OF THE RESOURCES : THE PROBLEM SPACE

With the advent of powerful and ubiquitous communication networks, there have had several proposals to "virtualize" the pedagogical resources used for learning whatever those are human, tutors, teachers, counselors, or media, documents. This started in mid 80's with the concept of Virtual Classroom coined by R. Hiltz [4]. Then in the beginning of the 90's with the concept of Virtual Learning Resources Centers, that we have used in the framework of a European project called CO-LEARN [5][6]. And more recently the concept of Virtual Campus, sometimes overlaid by the concept of Global Virtual University which has a more worldwide target. This evolution shows that the scope of the underlying systems and organizations, is more and more larger and that the integration issues are more ambitious and difficult.

Through these proposals, it is the affirmation that it is possible to learn whatever the place, the time, and the content or domain of interest, and, it lets one suppose the eventual mobility of the learner during his/her learning process. This process is like a long term transaction, so persistence is also an important issue. In order to clarify the requirements of the design of a Virtual Campus, the whole problem space must be clearly defined. The most important dimensions are:

- the time: the time constraints must be relaxed and the different rhythms of the leaning processes must be supported in respects to the pedagogical or instruction modes;
- the place: locations where learning takes place : home, enterprise, library, community center, or other places of socialization and fortuitous encounters;

- the population: from individuals or the tutor/learner pairs, often targeted in distance education, to groups or teams, the whole organizations and even their extensions (clients, providers), and finally large communities;
- the cognitive and pedagogical dimensions: plurality of learning styles, various theories of instruction, learning path more or less flexible, negotiation of the curriculum, etc.

This problem space shares a lot of analogies with those of the Computer Supported Cooperative Work domain of research where the principal dimensions, time and place, are often represented in a matrix which reflects the uniqueness of the dimensions for several users considered as a whole: time or location can be the same or different [7]. About time, it expresses the synchrony versus the asynchrony, and, about place, the co-location versus the distributed locations. In fact this 2X2 matrix can be extended to a 3X3 matrix if we consider that different times or places can be predictable (for example: remote learning centers) or not (wireless mobile stations). In each case, the coordination of activities, the communication fundamental characteristics (the common grounding, [8]), the appropriate instruction mode, or the social feelings are different and require a large variety of tools and user's interface environments.

Our aim with our project of a Virtual Campus System (VCS), is to support equally all these dimensions in an integrated framework centered on the learner activities. Our conceptual model of the VCS borrowed many ideas, methodologies and models from the CSCW field [5][9], with an emphasis on the modeling, specification and implementation of Computer Supported Collaborative Learning activities, CSCL, in order to enrich the autonomous and self-paced learning processes, favored by the VCS.

2.3. OUR DESIGN OF A VIRTUAL CAMPUS SYSTEM

2.3.1. *The specification of a Virtual Campus System: a Design centered on the Learning Activity*

We can summarize here the overall specifications which have been produced for our design of the VCS [9][10][11]. At the beginning, the goal was to support, through Internet technologies, the distribution of learning content for distance learning, or self-learning in local resources centers. Our major technical constraints were an easy access through a standard Web navigator and the support of the learner mobility : his own user's environment is not locked to a particular workstation. We wanted also to support a large range of CSCL activities [5] and for this purpose, to offer some shared workspaces, for groups, some private workspaces, and the integration, at a demand, of communication or groupware tools such as real-time audio-graphics conferencing systems, videoconferencing tools, textual "chat", and various asynchronous communication tools such as e-mail, forums, newsgroups or multi-user hypertext editors. From our previous project, CO-LEARN, we have learnt that it is counterproductive to design these tools by ourselves, so we decide to integrate existent, commercial or public, tools and to provide the glue to transform these tools into more cooperative, and learning organization-aware tools. A particular emphasis has been also put on the management, the work-flow, of the learning processes either individual (paths, agendas) or collective: coordination tasks, scheduling, resource booking, negotiation tools, etc.

The central concept of our design approach, is the concept of Activity, which has now a strong place in the modern approach of CSCW system [12]. From engineering viewpoint, in object modeling terms, activity is a first class object. This activity, individual or collective, is a flow of actions that the learner can or does perform, or is doing, either from the information viewpoint (to read, produce, transform, search a document) or from the communication viewpoint (to say, write, claim, etc.) or from the coordination viewpoint (to commit, accept, negotiate an action). This means that a task is assignated to a learner, or to a group of learners, at the beginning and, then, that this task and the resultant activity are manipulated by the different actors, participants in the VCS: learners, tutors, teachers or instructors and administrators. Our design of the VCS must support tailorability (design of new activity patterns) and self-organization for CSCL. From the engineering viewpoint, the activity is a complex object, part of the conceptual model, which is linked to other important objects: User-Objects, mandatory of the real users, which have organizational roles (rights and duties, reflecting places in the VCS organization) and functional roles (places in the activity, information and communication capacities), Artifacts-Objects (documents, tools), and Workgroup-Objects (user groups, shared workplaces, etc.). The Activity is the core of our design which gives a solid framework to support harmonious integration and the potential for long term and evolutive learning processes, which implies that the state of the activities, and their histories are persistent and stored in an appropriate database.

2.3.2. *The architecture and implementation of our VCS*

Our Virtual Campus is supported by a client/server 3-tiers architecture on the Internet [10].
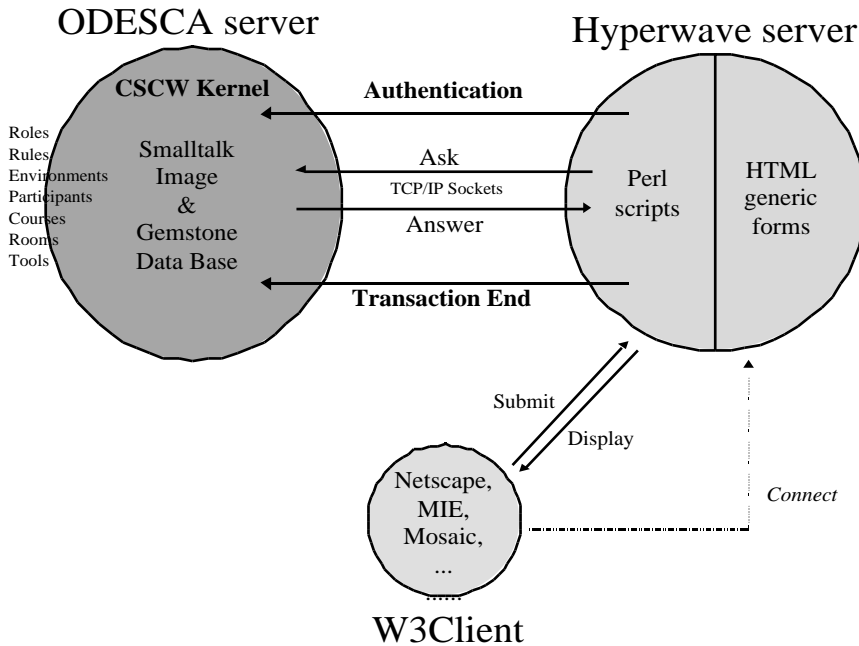
Figure 1 Virtual Campus System Architecture Overview

Persistence of documents is provided by a Web server, in this case Hyperwave (url : www.hyperwave.com), because it offers second generation features such as organization of collections of documents, efficient search mechanisms and access rights management. This middle-tier Web server is coupled (by CGI and sockets now, by CORBA in a future release) to an ODESCA (Open Distributed Environment Supporting Cooperative Activities) server, which stores and manages the CSCW objects : users, activities, roles, cooperation tools, cooperation rules ... This server is implemented by means of a Visualworks (TM) Smalltalk image and an object oriented database, Gemstone (TM) (url : www.gemstone.com). gives an overview of the system architecture. This database has been chosen in the past for two reasons : the ability to support multimedia objects used in the Web (for example Java applets) and its flexibility due to the scripting languages (Smalltalk or Java in this case). The ODESCA server provides the "motor" for the activity execution and management. For this purpose, we use several representations of the organization and of the various activities which are the result of the participative modeling phases implying the instructional designers and future administrators [5]. For example, the generic model for communication, used in asynchronous communication and coordination tools [11], is based on **Role-Objects**, **classes of contribution**, **rules** of conversation and **Functions** for an actions. The database is activated following the Event-Condition-Action cycle, ECA, which transforms it in an active database able to trigger actions from events. This approach is very flexible and tailorable. It can be compared to architectures based on intelligent mail handling systems [13] or on a workflow platform such as Lotus NOTES (TM) which has been used for the design of Learning Space (TM), some kind of a virtual

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new technologies for higher
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learning resource center (url : www2.lotus.com/home.nfs/welcome/learnspace).

User's interface provides facilities to navigate into the resources and activities supported by the VCS (urls: cueep.univ-lille1.fr).

2.4. SOME ISSUES DERIVED FROM THE DESIGN AND EXPERIMENTATION OF THE VIRTUAL CAMPUS

From our experiences and real uses of the different versions of our design of the VCS we can draw several issues for the future and the re-engineering of the VCS. We present now only some of these issues focusing on the user's viewpoint.

2.4.1. The user's interface issues

For the design of the user's interface,

especially the learner's interface, we have started with some results from the experimentation of our first project CO-LEARN. The design was slightly different because, even we use the same Activity centered approach, the interface was designed directly for a multi-windowing system, WINDOWS 95, and based on the ROOM metaphor. The learner navigated through the system, in fact the Activity space, by searching through different virtual places or Rooms dedicated to a particular activity : libraries for individual learning, classrooms for real-time distance teaching, or workshops for CSCL activities, etc. This initial choice of a spatial metaphor was in correlation with its presence in the field of Hypertext or in distributed collaborative environment such as the Mud's or the Moo's.

However the intensive experiences and
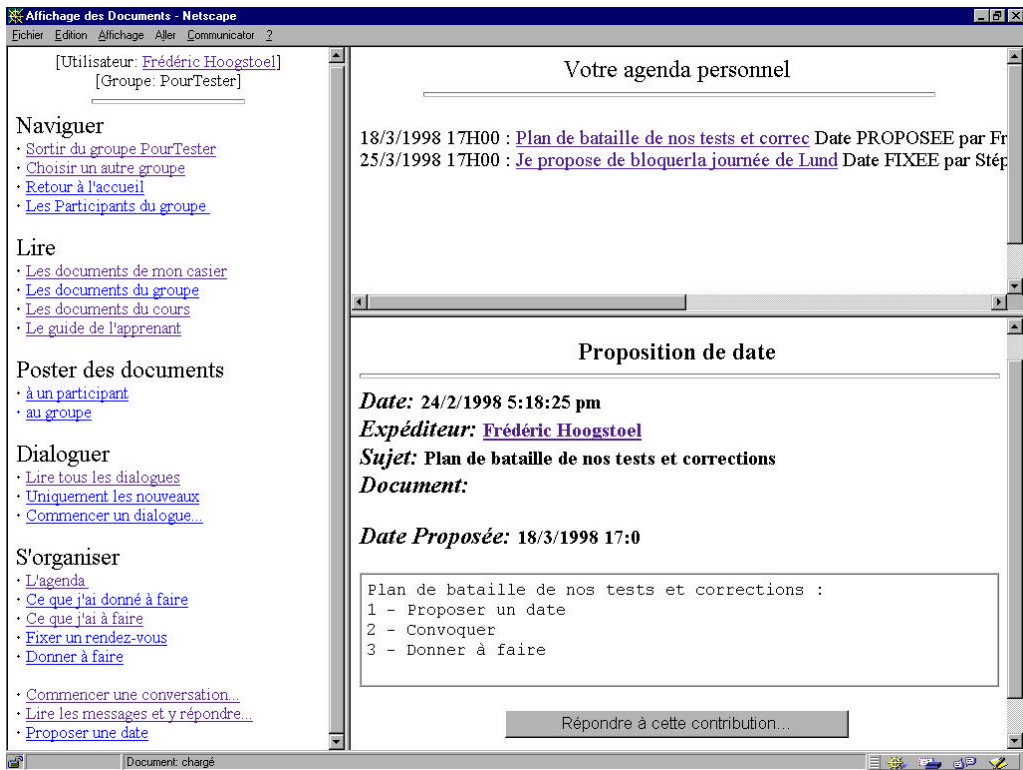
Figure 2: a sample of the user's interface

evaluations that we have conduct [14] have convinced us that, in spite of its user's friendly aspects, this spatial metaphor didn't work well in regard to the long term goal and the evolving autonomy of the individual learning processes. In particular it appears that this spatial metaphor didn't favor new collaborations, self-organization, coordination of collaborative activities, and finally it didn't provide real support for the learner's organization of her/his work and the planning of the relative individual or collective actions.

This explains why, in the present design of the VCS, we have changed the central metaphor for the user's interface. Taking advantage of the re-engineering of the user's interface to support Web access through a standard navigator, we have deeply changed the user interaction to integrate all the functionality around the Activity concept. This is provided (see figure 2 for a sample) by an interface centered on some kind of a learner's agenda: what (s)he had to do, what (s)he has committed to do, and then whatever the enrollments in different learning units, paths, etc. For this goal we use an environment of structured asynchronous conversation oriented towards learning organization and activity [9][11]. All is always a conversation about....something. As a result we provide a unique interface on the whole activities, where the actors are participants, and an organizational "glue" facilitating the contextualisation of the different tools and artifacts which are provided. From the technical viewpoint this is achieved by use of dynamic forms generated in function of the context, historicity and actions required. This new interface has proved its values in long term uses. Some evaluations are undergoing with specific and relatively complex scenarios, implying individual and collaborative learning in order to evaluate the potential of a learning Activity-centered design and the appropriateness of the user's interface. The first findings will be presented soon.

2.4.2. *The learning organization issues*

From our different previous experiments and real applications in the field, of our VCS, we can also draw several issues relative to the setting up and exploitation of such a system. These first observations, mostly pragmatic, corroborate or extend the first findings from our first implementation [15].

The use of such a technology in the field of flexible and distance learning requires a good and rigorous preparation and a very reliable supply chain, more stringent than in paper and post-office solution. The principal difficulty detected lies in the work done, before launching a learning unit, for the analysis of the expected learner's activities, both individual or in cooperation. This is a complex task for the instructional designer and/or the administrators, even done in cooperation with a system designer, because it requires solid capabilities to forecast the flow of the activity and the appropriate tools which will be necessary for the actors, learners, tutors, to achieve their goals. Only experiences, and probably a more user's friendly interface for the designer, can decrease this "work to do the work". We are presently designing a specific designer interface based on 3D interactions with the Activity server through a VRML browser.

We discover also that the learners don't fully use the potential offered by the VCS, to support the self-organization and non-planned collaborative activity. This is not due to the lack of collaboration awareness features of the system, which provides some clues to inforce this aspect with access to home-page of member of the group, etc. This is due to the difficulty for most of the learners to shift to a higher level, a meta-level, of observation and decision relative to their own learning process and progress. But it must be recognized that, if it is not really required in traditional education, this capability or skill remains one of the more important challenges of an educational system. It seems that our design has some deficiencies from this viewpoint because the present interface does not help sufficiently

the user to build a compatible and operational mental model of the learning activity which is proposed, and how to transform it. We are trying to propose some help in this interaction by using more graphical interface, i. e. some cognitive maps or conceptual graphs, in relation with the different already used HTML forms.

2.5. CONCLUSION: TOWARDS A SHIFT OF PARADIGM IN THE DESIGN OF THE NEXT GENERATION OF VIRTUAL CAMPUS

It seems to us that the design of Virtual campus or Global Virtual University needs some changes for the foundations themselves of their design in order to integrate new perspectives, especially social one. This is also advocated by scientists from the information systems fields. This can perhaps correspond to a shift of paradigm whose directions would be:

*   a client/organization relationship [16] [17]. This means that the design of the user's interactions must reflect not only the manipulation of elements of information or communication channels , but also the access to a human organization. In other terms, the interface leads to the totality of the dimensions aforementioned in the first part of this document;

*   a transactional dimension, potentially going to Electronic Commerce of the education tele-services. It goes in the same direction of the potential of Internet for extension of the other organizations such as companies with new virtual spaces supporting first Information, then the Communication, then the Distribution (management of flow of products, supply chain) and finally the Transaction: new channels for economic agents in order to initiate and execute commercial trade exchanges [18];

*   an articulation between the three levels of learning : individual, team or group and the learning organization, following the development in such an organization of Knowledge management [3];

We must also reconsider the learning process itself, which can be seen as an emergent and evolutive process. In effect, we see the problem of the control and management of this process, its directivity or freedom, its structures more or less restricting, as have been, in the past, subject to a movement analogous to a pendulum between two poles or positions:

*   one representative of a highly structured, in advance, learning process, exemplified by traditional distance learning systems with their strong background in educational technology and theories of instruction. In this pole the role of the media is important;

*   and another one less structured, more spontaneous, loosely planned, based on direct interaction between teachers/instructors and learners and relied on real-time audio video conferencing system or on group discussion. Most of the learning materials being produced on tap in this case.

It appears clearly that the available tools and computer environments are numerous for these two opposite poles. But is more probable that the learning processes as described at the beginning of this document, especially due to their social aspect and their situated nature, are rather emergent processes, mostly located between the two poles, than static processes locked to one of the pole. This recognition of the emergence phenomena, and then of its dynamic nature is the same as the reflections done in other fields of information systems such as Workflow management systems [19]. It is probably the next challenges of Virtual Campus System designers.

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3. RCTS: THE PORTUGUESE NETWORK FOR EDUCATION, SCIENCE AND TECHNOLOGY
INVITED PAPER

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Abstract - **Since the mid 80s the cooperation between universities and research centres lead to the creation of the portuguese academic and research network. It was also in this period that some kind of formal cooperation with the other european academic and research networks has been initiated. These efforts lead to the creation of RCCN, the portuguese academic and research network.**

By the end of 1996 and under the portuguese initiative for the information society the academic and research network has been extended to include a larger community of the relevant institutions in education, research and culture. This led to the creation of RCTS a network that promotes the rapid implantation of the information society in Portugal.

3.1. INTRODUCTION

In the framework of the portuguese initiative for the information society it has been identified that it would be very important to improve the use of information technologies and specifically the Internet by the portuguese academic, research and educational communities. To accomplish this goal the government decided to commit to the organisation that runs the Portuguese academic network the design and operation of a new network named RCTS (Rede Ciência, Tecnologia e Sociedade – Science, Technology and Society Network).

The RCTS network has as main objectives to improve the communications means of the following groups of institutions:

- Universities
- Polytechnics
- Public Research Laboratories
- Private Non-profit making research institutes
- Elementary and secondary schools
- Public Libraries

In additional to the connectivity aspects the network should try to devise a model where an effective cooperation among these institutions could be put into practice.

3.2. THE NETWORK INFRASTRUCTURE

The portuguese academic and research network has initiated its activities in the early 80s with an informal cooperation between several institutions, namely universities and a few private non-profit R&D institutes.

Around 1990 FCCN, after a request from universities, had the task of leading the development of the academic and research network. During the coming years the network has developed and was built using leased lines.

By the end of 1996 and due to the always growing use of the network, the government decided to increase the level of funding of FCCN in order to improve the quality of service provided by RCCN.

During 1997 there was a full migration of RCCN to greater bandwidth. The access bandwidth of universities has been upgraded to speeds between 1.4 Mbps and 10 Mbps, depending on the size and needs of the corresponding university. At present the network has the topology shown in Fig.1.

information and communication technologies. At present the capabilities of multimedia and also the Internet are two realities that a student cannot ignore.

It was taking into consideration these aspects that it was decided to connect all
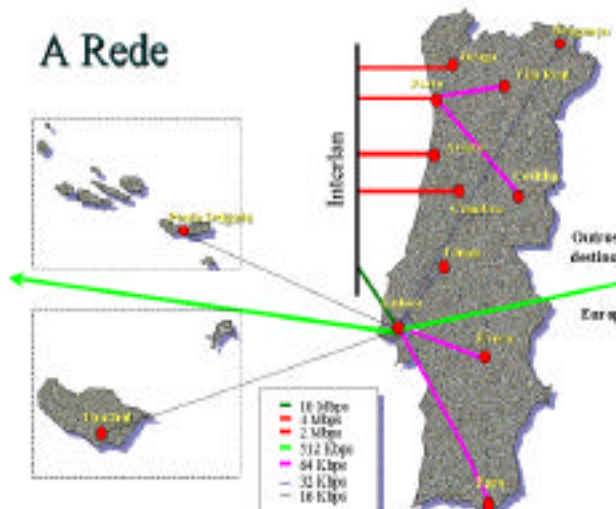
Figure.1 – RCCN main circuits

The network is mainly based on the InterLAN service of Portugal Telecom a broadband network that uses DQDB and ATM as base technologies.

portuguese schools and all public libraries to the Internet and equip them with multimedia computers (see at http://www.missao-si.mct.pt the goals defined in The Portuguese Paper for the Information Society). The goals to be achieved until mid 1998 where the following:

| 3.3. | EXTENSION OF RCCN TO SCHOOLS AND LIBRARIES – RCTS |

The new paradigms imposed by the information society require news skills and the capacity of learning along all the life. Indeed it is frequently recognised that many of the technologies that we shall use during our professional life have not yet been invented. Taking into consideration these premises the students must be prepared for a new reality: life long learning. In addition to the traditional teaching, the school must prepare the students to the new sources of information made available by the new

- connect all portuguese secondary schools to the Internet and equip all schools libraries with a multimedia computer
- connect all public libraries of municipalities to the Internet and equip them with a multimedia computer

In order to achieve this goal it has also been identified that a special cooperation between the above entities and universities and research centres should be created, to motivate a stronger cooperation between the

research and high level education system in the country, on one side, and the schools and libraries, on the other side.

In this context the schools and libraries have been connect using the academic and research network as the main backbone.

The task of connecting all schools and libraries to the Internet was quite large since it represents a significant technical challenge and also a major organisational effort. It also implies significant investments that had to be carefully planned. In addition the educational aspects in schools are a key factor in the whole process since many teachers lack specific training in the areas of new technologies and in most schools there is not relevant expertise in networking technologies.

Taking into consideration these aspects, namely the different development levels of schools and the need to control the technical and financial aspects of the overall project, it has been decided to adopt the following guidelines:

- In schools where there is already some activity in the area (around 15% of schools already had local area networks) this project should provide a good connectivity component
- In schools where nothing existed (or existed limited activity) a special strategy had to be devised in order to try to maximise the rate of success of the project providing them with a good platform to motivate the school to the benefits of information technologies
- The opportunity to connect schools to the Internet should also be used to open the schools to the new realities, namely the new media and the source of knowledge that they can bring

To accomplish these objectives we installed in the school library or in the public library a multimedia computer with two network connections. These two network connections have specific and important roles that must be emphasised:

- One ISDN controller provides a connection to a scholar PoP (Point of Presence) using an ISDN line installed in the school library
- One Ethernet controller provides a connection to the school local area network (in existence or to be created in the future)

Thus the multimedia computer has multiple functions: a) can be used as a multimedia Internet workstation opening the school library to the new frontiers of multimedia either on CD-ROM or via the world-wide Internet; b) act as a router between the local area network of the school and the Internet.

With this strategy we have a solution that can be tuned to the specific needs of the school communities along the country and, at the same time, provides a path for future migration.

3.3.1. *Connecting the Schools*

Another fundamental aspect of the project comes from the scholar PoP mentioned previously. Indeed schools and libraries receive their connectivity to the Internet through a PoP located in a university of a research centre. The objective of this approach, instead of using a commercial provider, results from the need of giving to schools and libraries specific technical and pedagogical support from network and education experts in the universities. Indeed a quite strong cooperation between the school and the staff in the PoP has proved very useful in increasing the success of the project.

The role of the PoP is very important in the philosophy of the project of this school

network. Thus we now present the main functions of the PoP.

The PoP is located in a university or research centre where a router with several ISDN primary accesses collects the calls coming from the schools. The number of primary ISDN accesses depends on the number of schools served by the PoP (on average a PoP serves 100 schools and has 3 primary ISDN accesses). In the PoP we also installed 4 servers that have specific task in the support to schools, namely: DNS server, mail server, news server, WWW server and proxy, remote file server, etc. The servers are permanently available to the global Internet. As a consequence pages placed by schools in

Finally in the design of the network it has been considered crucial the existence of very good quality content addressed to the target audience of the network: students from levels 5 to 12 and teachers. A highly skilled team with significant experience in educational telematics is responsible for all those contacts with schools not related to connectivity aspects (these are dealt by the PoP). A WWW server with educational content has been designed and set up (http://www.uarte.mct.pt). Its development and improvement proceeds with significant feedback from the schools.

The project has been designed during the early months of 1997. Starting in April 1997
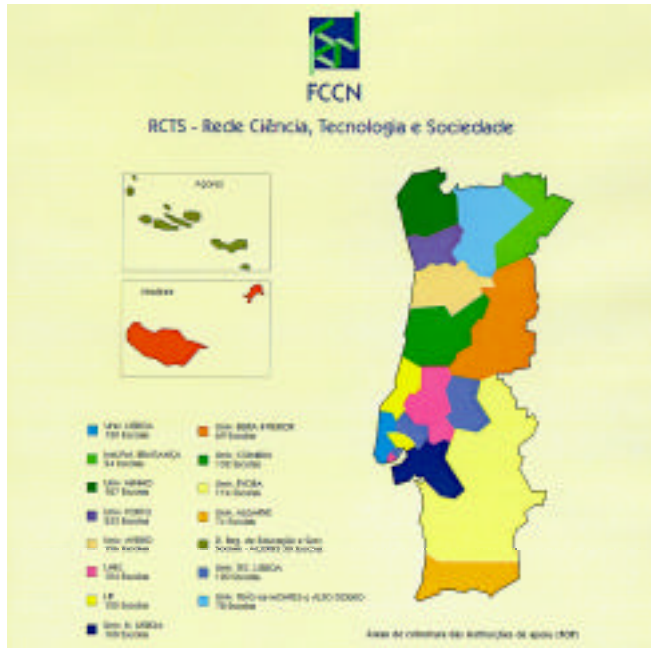
Figure.2 – The PoP geographical coverage

the disk space that is allocated to them in the PoP server are always available despite the fact that the school may be disconnected from the PoP (e.g., during the night or weekends).

Further information can be found at http://www.rcts.pt.

Portugal Telecom has installed the required 1600 basic ISDN accesses in the schools and all the required primary rate ISDN accesses in all the PoPs. During June and July 1997 the PoP equipment has been installed and all the services were setup. During the same period of time the computers have been

installed in the schools and a basic training about the use of the computer has been organised.

In the beginning of the school year, in September 1997, the school network has initiated its operational phase. During the several months of real operation of the network we have been dealing with the day to day support of the schools and libraries. Several seminars have been organised along the country, at each PoP, were 2-3 representatives from each school served by the PoP come to hear presentations concerning several aspects relevant for the PoP/schools smooth relation. During these seminars we also try to launch collaborative initiatives involving several schools.

The connectivity of the school network to the global Internet uses the Portuguese academic network RCCN as its backbone. Due to this design option, and to control the fair use of the backbone by either universities or schools, at each PoP a scheme of traffic balancing has been designed using a network load sharing router. Up to now this scheme has proved very efficient in enabling a fair use of the network by both communities.

3.4. ADDITIONAL DEVELOPMENTS

But an academic network can be distinguished from a commercially available network by a few key aspects:

- As the network is dedicated to a closed community the overall performance inside the community is higher than the one found in a commercially available network where very different kinds of users are present
- Trials of protocols and services are carried out and are specific to the academic and research community before a large deployment.

We will now shortly enumerate the applications and services that are under experimentation.

Video-conferencing services: this is an important activity for an academic network since several cooperative projects can have significant gains when collaborative tools are in place. For this purpose we are integrated in the MBONE and we are pursuing its implementation inside RCCN as a standard service. We are also testing the NetShow application in setting up dedicated video servers as well as using it for one to many video distribution.

Security services: after the participation of FCCN and other portuguese institutions in the ICE-TEL project, of the Telematics Applications Programme, an experimental certification authority has been established in coordination with the european root CA. We are aiming at a larger scale deployment of certification authority services to be used by a large number of users of RCCN.

The new Internet protocol: FCCN, together with the University of Lisbon, are integrated in the **6bone**, the worldwide backbone running the IPv6 network. FCCN believes that it is the role of academic and research networks to be one of the main sites where this protocol is tested and use. A IPv6 compliant DNS service has been installed and two IPv6 islands have been installed and are integrated in the 6boen using IPv4 tunnels.

3.5. FINAL REMARKS

The way to the Information Society requires new skills and the use of new paradigms in our daily activity. For this citizens have to be trained and must have access to information society tools and services easily.

The decision to use an improved academic
and research network as the networking
platform to build the schools network
imposed a few technical compromises but
has proved to be an adequate and cost
effective approach. In this way we have
achieved a fast rate of implementation of the
connection of all secondary schools to the
Internet and, using our concept of school and
library PoP, we promoted an effective
cooperation between universities, schools
and libraries that is already proving to be a
success.

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new technologies for higher
education

4. OVERVIEW OF EXISTING AND FUTURE EC SUPPORTED RESEARCH AVENUES FOR TECHNOLOGY ENABLED EDUCATION AND TRAINING
INVITED PAPER

The European Commission DG XIII
Peter Wintlev-Jensen

Abstract

An overview of the current EC research initiatives within the 4th Framework Programme, the associated research areas covered and the major expected results emerging.

An introduction to the strategic planning for future research, with a focus on the preparation for research activities within the EC 5th Framework Programme and specifically the research priorities and activities related to education and training, including the relationship with relevant EC educational policies.

5. SUPPORTING SUCCESSFUL IMPLEMENTATIONS OF LEARNING TECHNOLOGY

Nora Mogey, LTDI, Heriot-Watt University

Abstract – **Since 1994 The Learning Technology Dissemination Initiative (LTDI) has worked across the whole Scottish Higher Education community to support and encourage the integration of new technologies for the enhancement of learning. A range of different dissemination and support activities have been undertaken, and through working with different departments in different institutions it is now possible to draw broad conclusions about comparative effectiveness of different strategies.**

5.1. INTRODUCTION

The United Kingdom, in common with other countries, has a history of supporting the use of learning technologies within Higher Education, notably with the formation of the Open University in 1969. More recently Communication and Information Technology (C&IT) has been a theme for major national reports [1, 2, 3]. Since the 1980s the higher education funding bodies have taken a catalytic role, supporting the establishment of a number of ambitious initiatives. The Computers in Teaching Initiative (CTI) (established in 1984) has evolved from software development to a network of 24 subject based centres spread geographically from Aberdeen in the North to Brighton in the South, and from Belfast to Norwich. Each centre produces a newsletter or journal and reviews and collates information relevant to that subject which they disseminate among their cognate staff community. The establishment of CTI was soon followed with the Teaching and Learning Programme (TLTP) wich supported 76 projects throughout the UK,

committing over 30 million pounds, mostly directed at courseware development, and all specifically targeted at higher education. A further 32 projects, mostly with a focus on the integration of materials have been funded during 1998.

Within Scotland, the MacFarlane Report [1] argued for a central role for the use of technology within future higher education. As part of its response to the MacFarlane reports, the Scottish Higher Education Funding Council (SHEFC) established the Learning Technology Dissemination Initiative (LTDI) in August 1994, to support and encourage academic staff from institutions across Scotland with the integration of technology into their teaching. LTDI was therefor established at a time when there was increasing availability of software, but not very much practical experience of integrating those materials into courses.

5.2. THE LEARNING TECHNOLOGY DISSEMINATION INITIATIVE

Access to good quality software is not a sufficient condition to ensure its effectiveness and appropriate use for the enhancement of learning. The greatest barriers to the uptake of materials, apart from the current lack of recognition accorded to teaching and learning activities in comparison to research, are pressures on staff time, staff and student confidence, resource & support provision, and concern about the scale of change which may be initiated. During the past four years the LTDI has proved effective in promoting and sustaining the introduction and embedding of

learning technology into higher education courses across Scotland. LTDI is funded wholly by the Scottish Higher Education Funding Council, and all LTDI activities and publications are freely available to all staff in SHEFC funded institutions.

5.2.1. *Typical LTDI Activities*

LTDI activities are varied and wide ranging, but can be grouped under three broad headings.

5.2.1.1. *Workshop & Seminars*

These have been held on both a national and local or institutional basis catering for between 6 to 120 participants. Some events have had a subject focus, such as mathematics or modern languages while others have been generic e.g. evaluating learning technology , using technology to support assessment. All events are tailored to the particular target audience, and most have included active participation from the delegates.

5.2.1.2. *Information & Advice*

LTDI has established itself as a national resource, and the staff have unrivalled familiarity with the interests and experiences of a very diverse cross section of the academic community. Such knowledge is very difficult to synthesise or condense, but is invaluable in enabling LTDI to promote collaboration and networking across Scotland. LTDI staff respond to a variety of personal calls for information and advice, usually by telephone or e-mail. In addition the cumulative experience of the initiative has been collated in a number of publications, and also through a lively World Wide Web site (http://www.icbl.hw.ac.uk/ltdi).

LTDI is recognised as a publisher by the British Library; its publications vary from detailed guides on how to implement learning technology in courses, to quick sources of ideas given as lists, to case studies describing how others have used technology to enhance their course. All the publications are written in an easy-to-read style with expectation that most academic staff will dip into them, selecting relevant sections, rather than reading from cover to cover. All publications are freely available from the web site, and have been distributed widely throughout the UK and beyond.

5.2.1.3. *Implementation Support Service*

This is perhaps the most innovative part of LTDI provision, and that which has facilitated the greatest influence on the technology community in Scotland. LTDI staff have offered an Implementation Support Service, free at the point of delivery, to any department, or individual member of staff who has requested it. Implementation support can take many forms. Typically a department which is considering revising one of its courses may approach LTDI, and together we can explore whether the technology might usefully enhance the existing course, and if is felt appropriate then LTDI staff can help with selection of materials and the redesign of the course to ensure that the technology is fully embedded, not simply provided as an add-on-resource. Individual staff can also seek support from LTDI, for projects ranging from using e-mail for the submission of students assignments, to transferring from a traditional lecture based course to something which is wholly resource based and student-centred. LTDI support implementation projects by appointing on consultants with appropriate subject and pedagogical knowledge, and for as long as the projects can benefit from support.

Some comments obtained in response to the question "What were the most useful aspects of your contact with LTDI?" might give a flavour of the implementation support service:

❑ Practical advice about hardware needs;
❑ Encouragement in the design of the research project;

- ❑ Raising awareness among colleagues about the potential of CBL;
- ❑ Excellent one to one support;
- ❑ Ideas on how to evaluate software;
- ❑ Development of documentation;
- ❑ Confidence built in my ability to use IT;
- ❑ Because LTDI staff are subject specialists we could feel confident with them as teachers in their own right.

5.2.2. What factors have allowed LTDI to be effective as a national support organization

5.2.2.1. The Staffing Model

The staffing model adopted by LTDI has been to retain a core of staff from year to year, with new staff being seconded on an annual basis, sometimes part-time. Typically there have been three staff employed full-time on the project, with another three or four working anything from occasionally up to half time. It has been important to achieve a balance between retaining experience and knowledge while allowing new ideas to be developed and integrated. Seconding staff from teaching posts has many advantages. Each is an expert in their own subject area, and has credibility when advising other departments about possible courses of action. It is vital that staff have this academic credibility, but also that have practical experience of teaching students. Upon their return to their own institutions, seconded staff have frequently been delegated specific responsibility for aspects of technology support and become the focus for increased activity within that institution. It is perhaps worth stressing that LTDI staff generally have only a rudimentary grasp of technical issues, their background being firmly within educational practice and pedagogy.

5.2.2.2. Responsive & Flexibility

The LTDI approach has always been to be responsive and flexible. There is no fixed package to which institutions or departments are expected to subscribe. Just as the MacFarlane report stresses that higher education systems need to develop greater flexibility to support an increasingly diverse student population, so a national staff development initiative has to recognise that the needs of different institutions will vary.

5.2.2.3. Provision is free at the point of delivery

Resources within higher education are not limitless, and inevitably departments and institutions exercise control over how their budget is disbursed. By funding LTDI through 'top slicing' all the SHEFC funded institutions, the funding council at once signalled the weight that they considered should be given to new technologies and enabled all interested staff to access LTDI activities. There is no direct cost incurred by academic staff or to departments which might prevent them from taking up any LTDI services.

5.2.3. What Is Necessary within an Institution for an effective implementation of LT?

5.2.3.1. Emphasise pedagogy rather than technology

The most effective implementations of knowledge-media are always driven and led by the teaching and learning context rather than by the technology for its own sake. Carswell [4] expressed it thus: "It is all too easy to become engrossed in the challenges of implementation (what is possible), especialy if the pedagogic motivations (what is desirable) are not clearly established, and their attendant instrucional strategies are nor firmly specified. Focusing on what is possible tends to lead to simple translations of existing materials into a new medium, whereas reflecting on what is desireable has the potential of identifying underlying goals and supporting them through transformation of practice into a form that exploits the particular advantages of an alternative technology."

Laurillard [5] emphasised the importance of considering the implementation from the student's point of view "Student use of new technology does not occur in isolation from other aspects of their course as far as they are concerned. It must be embedded as a natural part of their learning, if they are to take it seriously, and to benefit from using it."So any institution keen to take up the opportunity offered by technology must support and encourage their staff to examine and revise existing courses. The real challenge is to allow that revision to be sufficiently thorough. The danger lies in making only marginal use of technology, viewing it as little more than a novelty factor within the student's wider learning experience [6].

5.2.3.2.   Support from Senior Management

The massive expansion in access to higher education, coupled with diminishing financial support from central government has posed a strategic challenge for most institutions. McClure et al [7] argue that the benefits of technology com only be measured in terms of institutional goals and policy, and in turn such a policy decision must be backed by appropriate investment

"Ultimately, every faculty member requires a unique information environment. Of course no institution can afford to support unique environments for each individual. The old model of subsidizing "technology" must be replaced by one that subsidizes institutionally important functions. The department subsidizes the activities important to its success, and the individual does the same for his or her success."

Successfull implementations of learning technology are frequently characterised by a clear sense of ownership for the academic or the departamental team concerned but such activities need to be drawn together into the overall intitutional framework. Omly senior management can really exercise influence on such a scale; where examples of such

commitment and leadership occur the effects are clear [8].

5.2.3.3.   Realism about timescales & resources

Leading change towards the effective use of new technology is not easy, even with clear educational objectives and the support of senior management. Change and its managment has been well researched and documented, and techniques established in other sectors have been applied to higher education [9]. In one of their sets of Case Studies, TLTSN identify a number of practical issues surrounding implementations, and resoursing in its widest sense in a recurring theme. Time does not need to be a problem, but thorough and well planned implementations can rarely be effected at high speed. Sufficient time should be allowed for planning, which usually means allowing far more time than can possibly be conceived as being necessary [10].

Realism is also needed when considering physical resources. Student access and hardware specification are both very important considerations, but it can be easy to overlook consideration of the diversity of support that may be required by staff or by students, on a wide variety of issues such as technical, confidence or subject specific skills.

5.2.3.4.   Evaluation & feedback

Despite general agreement about the importance of evaluation, it is often either neglected entirely or little more than an afterthought, with few resources devoted to investigating the real impact on learning of the use of new media [11]. It is also recognised that evaluating the use of computers in education is not easy [12], but there are case studies and experiences that can be cited. Gunn and Brussino [13] describe the use of Situated Evaluation of CAL (termed SECAL), and Draper et al [14] offer a variety of evaluation strategies.

Without thorough evaluation evidence, examining the whole experience for both the student and the institution, lessons may be learned and re-learned by individuals but little real progress will be made by the higher education community as a whole.

5.3. CONCLUSIONS

Key recommendations for the successfull implementation of learning technology are

5.3.1. *For the higher education community as a whole*

❑ Recognise, Value and Reward excellence in teaching as well as research; encourage thorough exploration of education and pedagogy as well as subjected based research.

❑ Encourage collaboration for the mutual benefit of institutions, staff and students.

5.3.2. *For individual institutions or staff*

❑ Design learning experiences tailored to address the desired learning objectives. Be led by the teaching not the technology.

❑ Strive for the support of senior managers

❑ Evaluate thoroughly, and respond to feedback from the students.

❑ Use the experiences of colleagues to build an existing knowledge. Learn from the successes and the failures of others.

LTDI has demonstrated that a centrally funded support initiative can be successfull in initiating and encouraging sustained change. SHEFC are currently reviewing their support provision for the Communications and Information Technologies, but the sector has indicated that continued support for the implementation of technology and staff development in this area should be a priority. It has also been acceeded that any future funding strategy should acknowledge the

longer term nature of facilitating effective change, hence an overall strategy for a number of years is preferred to one off funding for single academic sessions. An initiative such as LTDI can be a catalyst, but it is the enthusiasm and hard work of individual staff who really make the difference.

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6. A TECHNOLOGICAL RELATED DISCUSSION ON THE POTENTIAL OF CHANGE IN EDUCATION, LEARNING AND TRAINING

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Abstract - **This paper discuss the supporting role of Information & Communication Technology (ICT) in education activities and puts in context the impact that Computer Supported Cooperative Work (CSCW) can have both in Open and Distance Learning (ODL) and in general education, learning and training.**

A project where the author is working in the last two years, the NetLab concept, is presented and used to support the paper positions and serves as the base to propose a roadmap to a virtual university setting.

6.1. INTRODUCTION

At the end of the century education is on change. In particular, the high levels of students that miss presence classes and display a lack of interest to attend most of the subjects in their higher education is already a common problem for the great majority of european and north american institutions [1].

On-line applications in classroom education, a widespread trend in industrialised societies, can be distinguished from on-line education. The on-line education is now an important trend: in U.S., it has been estimated that 55 per cent of all the 2215 four-year colleges and universities have courses available off-site [2]. Many of the top-rated universities in the U.S. offer on-line degrees and act now as dual-mode education (providing on-campus and distance education) [3]. In Europe, the situation is different and although several universities have their programs the vast majority still lives in the "on-campus age". An early european innovator is the University of Twente that has some on-line programs but as complement to on-campus (see http://www.utwente.nl/masters/mscgen.htm). However on-line learning is extensively incorporated in on-campus post-secondary education in Europe, but few of them offer courses or complete degrees on-line [3].

What are the advantages of off-line campus? The main reasons are the convenience of place and time to learning, may be financially convenient for the student and rewarding for the educational institution [2]. But there is another reason that might contribute to the changing shape of the education needs. In fact, in a recent local inquiry [4] most of students reported that they want to work as soon as possible and they have a strong concern about their future jobs. They also declare that it will be better to pass shorter periods in on-campus activities and longer periods in a working environment. Many more studies reported similar situations where it seems to grow an idea of the uselfulness of longer period

degrees: time is playing an important role, as more and more lifelong education is a requirement.

In the traditional school environment, the central mode of learning continues to be face-to-face interaction between teacher and learner, however with a growing influence of asynchronous technological gadgets such as e-mail, web published information, Internet access and the use of CSCW systems and VR techniques. As reported by [3]: "O*n-line classroom applications have not been subject to organised production nor been explored commercially so far. Classroom education, however, can easily make use of instructional material produced for on-line education, in the same way that conventional education has absorbed much of the material prepared for distance education. In this respect, conventional schools and training institutions may constitute one potential customer for on-line education materials.*"

Many others reported similar trends, reinforcing however that traditional media still have a significant role, like the reported by [5], where it is expected that programmes and courses will remain fundamentally print based. The share of computer based digital segments and modules will rapidly increase and some figures are presenteded that support this trend (the ratio between print, electronic media and face-to-face sessions will change from 85:0:15 to 69:25:15 by the end of the year 2000).

Based on this context the author proposes a roadmap to a virtual university where content and actual facilities in higher education institutions present a major advantage. The resources (human, location, facilities and knowledge database) can be used to shift from traditional face-to-face sessions to a broader offer of learning facilities integrating both on-campus and off-campus activities. These new offerings act also as an innovation vector to introduce shorter and more learner-oriented education settings

6.2. A PROPOSED ROADMAP TO VIRTUAL UNIVERSITY

The Internet has been revealing as one of the great phenomena in what refers to the adoption of new information technologies by non-specialists with an increased number of people who have access to Internet from home [6]. And in schools numbers are also interesting with some U.S. studies showing that over one-half of American public schools reporting [7] insufficient capability in technological infrastructures, but Internet access was possible (1996 figures) from 65% of the schools and 14% of the classrooms [8]. In Portugal [9] and in most european countries similar programs to enhance Internet use in schools are taking place or starting. This will lead to a different kind of student in higher education on the coming years.

From the reading of the different literature it can be listed four general measures that have been taken to introduce networks and connectivity in elementary and secondary schools:

- teacher training for global connections
- introduction of modern computers
- every classroom tied to the global network
- effective software and on-line curricula

The use of the Internet introduces a new way of working with information and even knowledge, creating alternative forms of study and of research with direct impact in the process of Teaching-learning [10] and [11]. Another great potential is the possibility to communicate among students and between professors and students in new forms, starting new ways of collaboration mediated by technology [11].

These possibilities are made feasible by the availability of existent infrastructures: a local area network, the fact that every student has his own laptop computer and the existent

network entry points in the classrooms, in [13], a discussion of the Internet impact in the process of Teaching-learning is made.

6.2.1. *The environment: Fernando Pessoa University*

University Fernando Pessoa is the merging result of two Institutes in the year of 1994. It is located in Porto, Portugal's second large city. The University (1998 figures) has 4900 students, 380 lecturers and an administrative staff of about 80 people. The students belong to four different departments: Administration Sciences, Communication Sciences, Political and Behavioral Sciences and Science and Technology, with an offering of eighteen courses and three graduations.

The first year students of all courses have a laptop computer as a requirement for admission at the university. The minimal specifications for the laptop computer include the Microsoft Office Pro student licence.

The university network infrastructure is based in LAN connectivity. It started late 1995, with Ethernet 10 Mbps LAN in labs and classrooms, with 170 DHCP entry points and 1 server (Windows NT, Intel box). In 1996 it evolved with LAN segmentation with 300 entry points, including the library. In this phase where started university Intranet services: www, ftp, mail, proxy, mail and news server, with a 64KB WAN ISDN line to Internet. In this phase the network has 5 servers (include two Sun boxes). In 1997 the LAN segmentation continued (with some segments with 100 Mbps), and the number of entry points is now 400. The network has now 10 servers (with Solaris, Linux, and NT).

The actual numbers of laptops computers at Fernando Pessoa are 2300 for students and 100 for teachers. This makes that the actual infrastructure at Fernando Pessoa has coverage of 1 entry point for each 5,75 students or 1 entry point for each 6 laptop owners. Over the years the use of shareware

and freeware has increased (consequence of Internet use, from none to almost 65% of total used software); more information can be found in [13].

6.2.2. *The NetLab concept*

Every student can connect to the network using their own computer or through the campus facilities. Students will be able to use networked facilities, and set up projects on their area: Advertising, Marketing, Anthropology Studies, Communication, and Business on-line. The massive presence of laptop computers now makes part of the IT infrastructure of the university. This affects in a different way the needs and the use of a Campus Wide Information System - CWIS.

As seen in Figure 1, it is possible to consider the technological infrastructure just as the first layer that can enable the production, communication, change and share of content between students, students and teachers and even between teachers by linking computer resources and their respective contents [14].

In that approach it is possible to have an experimental education lab where innovative situations can be tested. An example is the group assessment where three students make an exam: one at the classroom, another in a social location and the third in the library,
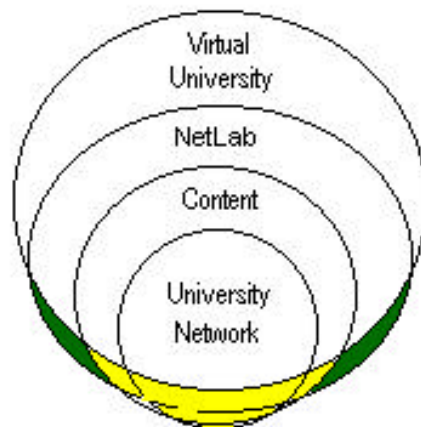
Figure 1- the NetLab concept

each one with their functions and communicate between them using the network and its favorite computer tools [15].

The system itself can be a good prototype for a local information society where different people from different courses can interact using a strong digital base for its relationship [16]. One example could be the call for help in student's projects from subjects more related to some courses then others, or initiatives like the ecological interest group, *Geonucleo*, that have their own web pages (http://www.ufp.pt/units/geonucleo/default.html).

The NetLab does not intend to be neither a virtual campus network nor a distance learning environment. It wants to be a local interaction engine that provides a structured approach to services and content generated both by students and professors.

6.2.3. *NetLab contributions*

But what is really different in NetLab? First, it is people-centered and not technology oriented; second, the environment where NetLab exists has a strong reinforcement in mobility (with laptops and DHCP network entry points); third, it provides a greater involvement between students and university by sharing of technology investments.

At last, because the network allows the use of tools for information manipulation from classrooms to all spaces of the university (this brings new concepts of multidisciplinary projects; the class that never ends, new forms of interacting between students and between students and teachers and even between teachers).

The NetLab can be seen as a first step to prepare and prototyping on-line material and off-campus on-line courses and train teachers to integrate ICT technologies in the Teaching-learning process. When integrating these goals with the various resources,

information technology and adequate organization, the institution can shift to offer on-line degrees off-campus and offering ODL courses as a normal part of its service catalogue. This situation has been defined as corresponding to the ones in reporting as virtual university [17].

Before NetLab layer (figure 1) stays the content layer and the technology itself. First to enter discussion on the technological aspects it is important to discuss the content layer. It is a major advantage for most of the higher education institutions because they constitute the great producers of content material and to have a proper workforce to maintain these materials update and usable. To get the students involvement and even other teachers' involvement, it is necessary to gather content and publish it on-line. An example of multiple content offers is the author's homepage
 (http://www.ufp.pt/staf/lmbg/).

6.2.4. *Get the potential users involved*

As potential users of the NetLab we have the people who use the university labs and the laptop owners (students and teachers).

Different strategies of user involvement must be used for the two groups described. The easiest one is the student group and a more detailed discussion can be seen in [18].

The more difficult group is the teachers group. The challenge is how to develop a "*can-do*" attitude to: 1) teachers start to use ICT in the development of their own learning materials; 2) make advantage of the laptop and network in their own classes; 3) use the network to communicate with students and other teachers; and finally, 4) become publishers and permanent developers of on-line material.

Teachers are right fully cautious about anything that changes the relationship between student and teacher and this is what happens with NetLab; [19] reports that when

introducing 3 to 6 computers into a classroom changes social relationships.

On the other side, teachers have a crucial role in the technology adoption and [19] reports a strong correlation between curricular relevance and teacher interest. The same author also states that increase in the number of computers will make a difference on a school wide basis if the first go to teachers who are natural leaders and active in school networks.

A simple strategy to spread the system use is by stimulate a multiplication phenomena to "*pass the practice*" between teachers. An example is an american case where 100000 teachers train at least five other colleagues to use technology as a tool for teaching and learning in a plan called 21st century teachers (http://www.21ct.org).

As a final remark, there is no evidence to suggest that classroom instruction is the optimum delivery method. Distance education is often more individualised and personal than face-to-face instruction [20].

6.3. TECHNOLOGIES

When dealing with technologies some issues must be well planned especially in an environment with great number of systems owned by multiple kinds of users. This can get even more complex as it can be stated that technology are less stable resources then users and work practice are. In complement, technology is developing astonishing fast and the users (especially teachers) have just become aware of a potential drastic change of the (traditional) work practice [21]. This forces a need for a strong support to keep working hardware, software and network resources (both from users and from university).

Four questions arise when dealing with information technology to harness the NetLab, first proposed by [22] and adapted here:

- *Connections*: how can computers intelligently connect information seekers to sources?
- *Utility*: how can information access be complete (recall), correct (precision), timely, felitious, transparent, authentic, authorised and secure?
- *System evolution*: what architectures can best leverage rapidly changing information environments?
- *Collaboration*: how can groups of people and computers co-operate effectively over distributed networks?

Schools and universities today emphasise working in isolation; however, digitalisation will encourage teamwork [23]. This is reinforced by [24] which states that western business, social and academic culture is ruggedly individualistic; education's focus is on individual performance while employment performance assessment is based almost exclusively on individual performance. Some experiments with group assessment are reported in literature [25]. To confront students with group work, teachers must explicit teach and model teamwork including it in curricula because as [24] states, technically competent students are actually deficient if they cannot apply that competence in a team setting. We can say that co-operative learning is a recent concept as a way of thinking about and conducting the educational process. Although co-operation in learning is not in itself new, the idea of "cooperative learning" as a particular system of learning is [26]. We can found in the literature many references to Computer Supported Cooperative Learning (CSCL '95, the first international conference was held at Indiana University http://www.cica.indiana.edu/cscl95/). The support from computers can be done by the use of web facilities and on-lines tools as the ones reported at

(http://www.iis.sinica.edu.tw/CCL/html/rela
ted.html). The functionality of these systems
is discussed bellow.

6.3.1. *Cooperative learning for use in CSCL*

Co-operation is defined by [27] as "*acting together, in a coordinated way at work, or in social relationships, in the pursuit of shared goals, the enjoyment of the joint activity, or simply furthering the relationship*". [26] refers that co-operation "*is seen as central to our everyday lives*" and "*cooperative learning is process driven*". In the definition of the group, [26] states that a human group is a collection of individuals, who have interdependent relations, and who perceive themselves as a group that is recognised by non members. Finally, group members have interdependent relations with other groups and whose roles in the group are functions of expectations (internal and external). [26] concludes its reasoning saying that people working cooperatively in CSCL environments do work in groups and that these groups work in complex ways. In open learning situations where there are many different simultaneous influences on the group including distributed systems and the use of virtual technologies to augment the group environment it is possible to add some influences from beyond the social structure of the group itself [28].

Co-operative (or collaborative, as it also called) work produces information products like decisions, designs, analysis, minimises information loss, operates a finer level of details [29].

What are the outcomes of cooperative learning? In their work, [30] looked at 323 studies and concluded that cooperative methods lead to higher achievement than competitive or individualistic ones. Other study, [31], states that cooperative learning increases the positive affect of classrooms and students working cooperatively become more cooperative; they learn pro-social

behaviours such as how to get with others, how to listen and so on. At last [32] suggests that cooperative learning fosters knowledge about the learning process.

In addition to the individualistic and competitive learning goal structures, the cooperative one can be relevant to education, learning and training, justifying the introduction of ICT that support it.

6.3.2. *The use of CSCW systems*

CSCW as a study area, can be considering as a sub-topic within the broader field of Information Systems [33]. With the use of Computer Supported Computer Work systems one can expect to extend the study of learning environments to work environments.

In the keynote address to the Fifth ECSCW conference, at Lancaster, [33] states that a CSCW system implies four items: a group of people; their would-be cooperative activity: an organisational context of some kind and technology supporting the group activity.

A core rationale for CSCW is proposed by [33] and visualised in figure 2 where when
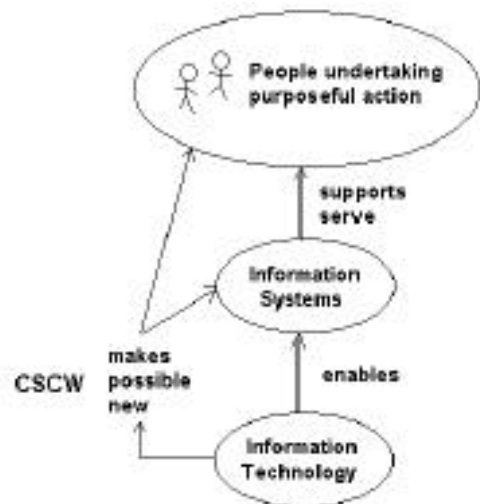
Figure 2 - a rationale for CSCW [33]

information technology IT is in an enabling role its possible to envisage new forms of purposeful action (both individual and group action) which would not otherwise be possible. We must note that information systems process relevant data in order to support or help people undertake purposeful action and IT enables such support to be realised.

The goal of CSCW is to discover ways of using computer technology to further enhance the group work process through support in the time and place dimensions, where the focus of CSCW goal is the social interaction of people, and not the technology itself [34].

6.4.   CONCLUSIONS

Internet and ICT based open and distance learning (ODL) are rapidly gaining popularity and importance as means of providing lifelong learning (LLL) [35]. Use of new technologies like CSCW and VR can enhance collaboration, foster knowledge representation and developed systems that provided vicarious experience.

It also provides means to augment teaching and learning skills of all the users involved, creating new forms of interaction, dynamic information representation and relations with the learning community in multiple time/space alternatives.

Developing a chain reaction of production and refining learning materials on line is the general NetLab's idea (as a multiplication factor for reaching other teachers).

A main concern in NetLab is drawing an emotional agenda to involve students and teachers. Psycho-pedagogical studies in the educational field have shown that students can better learn by managing, manipulating and organizing the information on their own [36] (we can expected that the same applies to teachers).

This way the author believes that staying tuned to the NetLab concept can grew the

potential of a higher education institution, and offer it a path to evolve to a virtual university.

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univ... d'...é. 98
new technologies for higher
education

B. Cognitive Processes and Pedagogical Experiences

Invited Lectures:

R. McAleese, "*Coming to Know: the role of the concept map - mirror, assistant, master ?"*

S. Foti, "*Designing and Integrating Technology rich Curricula*"

S. Grabinger, "*REAL Strategies for Distributed Learning Technologies*"

C. Fiolhais, "*Difficulties in physics learning - students conceptions and computational methodologies*"

B.Sommekh, "*The role of evaluation in ensuring excellence in CIT initiatives*"

Communications:

A. L. Neves, A. D. Figueiredo, "*Modeling a Web-based Educational Environment*"

C. M. Santos, A. R. Borges, "*How to use Interactivity in an effective way: a proposal*"

F. Sansonetty, J. P. Robinson, N. Lau, B. S. Santos, R. Alves, L. Silva, J. S. Pinto, "*Simulations for facilitating self-training in flow cytometry: Discussion of the concept and its utility*"

J. A. F. Trindade, C. Fiolhais, "*Virtual Reality in Science Education: The Virtual Water project*"

R. McAleese's, "*Coming to Know: the role of the concept map - mirror, assistant, master ?*", deals with the exploration of a cognitive model - the concept map as a technique to formally represent knowledge, and its roles as an assistant, or mirror, to learners, as well as a frame determining what can be learned. A review of the author's work, the paper provides also a new explanation of the process of creation and management of concept maps.

S. Grabinger in "*REAL Strategies for Distributed Learning Technologies*", presents his research on environments for active learning, largely based on the same models as McAleese. The belief that "technology must serve the pedagogy, not create it" underlies his argument. S. Foti's "*Designing and Integrating Technology rich Curricula*" describes a model for course development being experimented with at his institution, the University of Florida (USA), an activity-centered model emphasizing interdisciplinarity and collaborative work.

C. Fiolhais, "*Difficulties in physics learning - students conceptions and computational methodologies*", describes his research findings on the conceptual difficulties students face when learning Physics, and how computers can be used to overcome them.

B.Sommekh's, "*The role of evaluation in ensuring excellence in CIT initiatives*", draws on several evaluation studies she has been involved with to identify characteristic shortcomings of R&D projects in the field of new technologies in Higher Education and suggests ways in which these can be minimised.

In the communications by young researchers addressing the theme, C. M. Santos "*How to use Interactivity in an effective way: a proposal*", F. Sansonetty, "*Simulations for facilitating self-training in flow cytometry: Discussion of the concept and its utility*" and J. A. F. Trindade, "*Virtual Reality in Science Education: The Virtual Water project*" describe the development of CBT materials in the fields of Programming, Biology and Physics. A. L. Neves, "*Modeling a Web-based*

online educa berlin 98
new technologies for higher
education

Educational Environment", of a more theoretical nature, proposes a model for the representation of educational intranets using the Unified Modeling Language (UML).

7. COMING TO KNOW: THE ROLE OF THE CONCEPT MAP - MIRROR, ASSISTANT, MASTER ?
INVITED PAPER

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Abstract - The concept map is becoming a ubiquitous tool in education. In recent years there has been a growing interest in "diagramming" or "mapping" ideas to be learned. (e.g. Jonassen et al, 1998) The approach has been championed by study skills proponents such as Buzan (1993). Maps of concepts and relationships have been used by many researchers and practitioners to help diagnose misunderstanding , improve study methods and glimpse how learners come to know. In other areas, the representation of knowledge in formalisms such as the net greatly assisted the development of intelligent tutoring systems. (e.g. Sowa, 1983) In order to better understand the claims made for its efficacy, reference to how concepts maps have been used and defined will lead to a plausible explanation of the process of "off-loading" of concepts during learning or study. (McAleese, 1994,1998) In order to demonstrate the widespread application of supporting learners with external "learning spaces" (c.f. ISLEs/ and REALs - MacFarlane, 1993, Grabinger et al , 1995, 1998) consideration will be given in this paper to techniques that <u>formally represent</u> knowledge in Concept-Relationship-Concept "instances". (Fisher et al, 1990) Other techniques such as reflection journals draw on the same process but are not considered in detail here. The importance of self-regulation (Zimmerman (1990) and self-confrontation (McAleese, 1985), is highlighted in this framework. The map as a mirror or an assistant to learners is well documented (e.g. Vizcarro & Leon, 1998); the question of an external representation of thinking in the form of a map <u>determining</u> what can be learned as well as what might be learned, is not yet fully known.

7.1. INTRODUCTION

"…..It is in these shimmering and incessant embraces that the infinite patterns, the infinite Maps of the Mind, are created, nurtured and grown. Radiant Thinking reflects your internal structure and processes. The Mind Map (Concept Map) is your external mirror of your own radiant thinking and allows you to access this vast thinking powerhouse……"
(Buzan, 1993)

This paper provides a new explanation of the process of creation and management of concept maps. In so doing, it extends what is known about an important self-regulatory process in study and learning – reflection. This paper uses "reflection" as a focus for its argument. Reflection is the self-regulatory process that is under the control of the learner. The processes at work are wide ranging – stretching from motivational issues and self-efficacy to the recording of what is known using a net metaphor – the concept map. The paper makes a claim that both symbolic representations of what is known (e.g. concept maps) and language based representations – e.g. the reflection journal (see Gardiner & McAleese, 1998) can be understood in terms of resolving a tension between what is known and stored as cognitive operational models and what is

recorded in a map or in a journal. Central to both is self-regulation. (Zimmerman, 1990; Zimmerman & Schunk, 1989) The process of self-regulation is essentially a cybernetic process. Norbert Wiener called this "the field of control and communication theory… whether in machine or in animal…" (Wiener, 1948) [1] Self-regulation involves intra-personal communication – what Gordon Pask would have called meta-communication based on conversation theory (Pask, 1984) Learning involves considerable intra-personal communication while the learner reflects IN action or reflects ON or FOR action. (see Schön (1983; 1988) and Cowan (1998). The control in Wiener's definition of cybernetics is manifest in learners making sense of sensory experiences and the matching of internal representations with external manifestations. (See Kolb, 1984) An examination of what concept maps are will lead to a broader discussion of the cognitive processes involved in their construction and maintenance.

7.2. WHAT IS A CONCEPT MAP?

7.2.1. *Background and Definition*

There is considerable literature on concept mapping. (see for example, Bogden, 1997; DeBono, 1993; Deikhoff (1982); Gaines & Shaw, 1994); Gold, 1984; Kommers, 1992; Reader & Hammond, 1993 [2]) A concept map is a directed acyclic n-dimensional graph consisting of a set of m Concept Labels $\{C_1 \ldots C_n\}$ [3] and a non-empty set of r Relationships or Arcs $\{ R_1 \ldots R_n)\}$ The representation of an idea does not determine its truth value as individuals may hold "non-truthful" understandings. The representation of these sets is in terms of a diagram. [4] Strictly the map is a graph – however hand drawn and computer generated maps are diagrams. Different representational forms are used to make diagrams of the graphs (Jonassen, 1998). The

most popular – in terms of study aids – is the Mind Map (Buzan(1993). Work in this paper uses the Node-Link-Node instance associated with Kathleen Fisher (1990) and Jo Novak (Novak & Gowin, 1984) The present author has provided some additional definitions of maps in earlier papers .(McAleese, (1987; 1990; 1992; 1994; 1998)

7.2.2. *Maps Signify Virtual Conceptual Structures*

An important issues is the virtual nature of the concept map. [5] a concept map can be n-dimensional. In other words, the "map" can exist in n-dimensional space. This is the result of two properties. First, each node itself being a sign for a more complex understanding comprising of nodes and relationships. So, in the node {CLASS} in Figure 3 (below) can be "de-compressed" (see, West & Pines, 1985) into a further map. (Figure 4). [6] The concept label {CLASS} is an incomplete model of the understanding the author has of " an inter-institutional collaborative project that set out to produce study skills materials for undergraduate students…". The concept label {CLASS} is used as a "place holder" for this more complex understanding. Second, relationships exist between the nodes in the "sub-map" created at the {CLASS} node and concept labels elsewhere in the map – shown in Figure 3 and in other "sub-maps". Figure 5 shows an incomplete map for a node {innovation strategy} which has links to the {CLASS} map and other sub-maps. These relationships and de-compressions give rise to a recursive system. Each node may be de-compressed into one or more nodes which in turn may have relationships with any other node in any other "sub-map". This is the n-dimensional nature of concept maps. Recursive dimensionality is brought about by the "de-compression" and "compression" of concept models signified by concept labels. This gives rise to two "laws" of concept maps. First, it is likely that the level of "de-

compression" is a function of working memory and this would suggest that concept models are: "**L1**: *represented using the least number of concept labels and relationships - for the current understanding*". This leads to a second law: "**L2**: *each and every concept label signifies an indeterminate number of other related concept labels*". Concept maps have to be seen in virtual space – not planar or Cartesian space. The relationships between nodes can be thought of as "deep" as opposed to "surface" linkages. The relationship of concepts - one to an other - can be understood in terms of structural knowledge.

7.2.3. *Structural Knowledge*

The nature of what might be represented has been clarified by Quillian (1968) others (e.g. Donald, 1986; Jonassen et al , 1998b). Dave Jonassen has made a plausible case that concept maps provide a measure of structural knowledge. [7]Such knowledge ".. knowledge of the interrelationships of ideas with a knowledge domain.." (Jonassen, et al 1998b; Jonassen, et al 1993) suggests that there may be an isomorphic relationship between what is known by the learner and held as such and the external representation - the map. Jonassen, et al (1998) seem to say that the map is a dynamic construction that comes about as a result of the experience of mapping. In writing about mindtools, Jonassen et al suggest "....mindtools represent a constructivist use of technology. Constructivism is concerned with e the process of how we construct knowledge.."(Jonassen, et al, 1998) The assumption here is that the maps comes about as a result of engaging in or constructing understandings. This is the "constructionist" view. However, in an other paper, the same author claims "..concept maps .. are the spatial representations of concepts and their interrelationships that are

intended to represent the knowledge structures that humans store in their minds…"(Jonassen et al 1993; Jonassen et al, 1998) This is the "representational" view. In Jonassen's writings – he allows the maps to be BOTH representational and constructive. This tension is important in understanding what maps do and how they facilitate learning.

The current author would take a much more constructivist view – given the dynamic process of mapping. Concept maps are not snap-shots of what is known - rather they allow off-loading of thinking and show the result of engaging in knowledge construction. As structural knowledge, concept maps are not isomorphic of what is known. They can not therefore be used – as such – to evaluate what learners know – rather they allow learners an opportunity to <u>engage in</u> the process of learning. The distinction is made even more forcibly by Jonassen & Marra (1994) in a response to the McAleese (1994) paper. Jonassen & Marra suggest that maps can not ".. adequately reflect what is really in the mind .." as knowledge is "… dynamic .. not static" (Jonassen et al, 1998 citing Jonassen & Marra, 1994). They claim that concept maps are (therefore) dynamic and process oriented. They are not snap-shots or representations of pre-existing structural knowledge.

7.2.4. *An Example of a Concept Map*

An example of a map can be seen in Figure 1 which was drawn by a student using a concept Mapping program – Inspiration – as a study aid. [8] This map comprises 50 nodes; with 49 relationships - 19 of which are labelled. [9] At first sight, the map looks complex and confusing. However, it was produced by an individual student – who is unique – as a <u>personal</u> study aid. It is NOT a definitive representation of what is known about "brewing in the United Kingdom". It is

also important to note that the map was created over a period of time. [10] The learner was engaging in a process of reflection IN action, reflection ON action – with regard to a chosen topic. [11] The map is an external mirror of the student's "…radiant thinking…."(Buzan, 1993). Jonassen and others (Jonassen, Kommers and Mayes, (1990) ; Kommers, (1992)) have described the concept map as an instance of a "mindtool". [12] As such, a concept map functions as an aid – helping the learner interpret and organise personal knowledge. A mindtool allows the learner to interact with their own understandings through some external manifestation. The simplest manifestation is to allow what is known to be represented in terms of nodes and relationships/ arcs. (McAleese, 1987) The simple cognitive process that generates the sets of nodes and relationships is associationism.

7.2.5. *Associationism*

The idea that one concept generates links with another concept and that the building blocks for thinking are related as chains or cascades can be traced to Aristotle. In a well cited reference to James Mill (1829) the cascade of thinking is well exemplified. "When I see a horse that is a sensation. Immediately I think of his master, that is an idea. The idea of the master makes me think of his office – he is minister of state.. the idea of a minister of state makes me think of public affairs…." The cascade of associations is the triggering of Concepts that one Node creates in the mind of the learner. The learner in making sense of an idea uses a conceptual model comprising linked or associated nodes to store understandings. Associationism is also exemplified in hypertext and hypermedia. The original idea of hypertext (Bush, 1948; Nelson, 1988) used the associative power of the mind to build complex webs of inter-

related ideas. While the term hyper-media is now used widely to imply any multi-media presentation where the user can exercise choice on what is read/ seen/ heard – the essence of hypertext/media is that of associationism. Individuals browsing through hypermedia documents or chunks are using associations to determine what node is visited next. (see McAleese, 1989 for a discussion of browsing in hypertext) This process is a self-regulated process. The question of self-regulation needs to be examined in detail.

7.3. SELF-REGULATION

Self-regulation forces and keeps the learning process "ticking over". (Schunk, 1989) Self-regulation is that control mechanism that makes individuals goal directed and assists in implementing intentionality. (Zimmerman & Schunk, 1989) Without an ability to plan for action and know what tasks need to be carried out and the ability to assess how successful action has been to achieve goals, an individual would not exhibit what we judge to be rational behaviour or achieve academic success. Organisms can either exercise this control themselves or have it imposed on them by some other agent or system. In practice individuals are effected by control mechanisms that are both external and internal. There is a resultant balance sought and achieved between these competing forces. This balance is referred to as locus of control (LoC). Rotter (1966) defines LoC as ".. the manner in which a person feels he himself (internal control) or factors in the situation (external control) determine his behaviour…" That is, the initiative to act or respond is determined by factors which may or may not be within the control of the learner. LoC is a way of describing the balance between competing forces which act to control systems. If the learner does not believe that events are brought about as a

niiwcr=ifr.v.icz. 98
new technologies for higher
education

consequence of their actions, the LoC is said to be with the system. [13] LoC seems to have two theoretical perspectives – according to Rossouw & Parsons (1996). The first, a social learning theory perspective – in which the learner (students) are primarily concerned with "…the identification of individual… tendencies in (the) perception of control.." The second perspective, an attribution theory perspective, ".. focuses on the identification of situation specific variables…". Studies of LoC suggest a complex tension within students which may be brought under control if students have the ability to reflect on their state and disposition. (Craig, et al, 1984) In addition to planning and evaluation, learners need an approach to external tasks and situations that Donald Schön has called Reflection IN Action and Reflection ON Action (Schön, 1983,1988) The concept map establishes self-regulatory effects in learners. The LoC shifts between the conscious self-regulatory learner and the external locus – the concept map (see below). A component of self-regulation is self-confrontation.

7.3.1. *Self-Confrontation*

Self-confrontation is a process closely associated with metacognition (Osman & Hannifin, 1992) and reflection and is associated with the cognitive-constructivist view of self-regulation. Self-confrontation is the external juxtaposition of self-concept, feelings or beliefs with some external physical manifestation of those feelings, beliefs etc. The best known situation is where a learner is able to see or hear a recording of the post-performance of some skill. For example, in sport, it is common in training to use video recordings for feedback in swimming, golf and tennis. In essence, a video record is used to confront or show an individual how they performed. It is therefore a **performance aid**. Within an educational and psychological context, video

has been used for both training and counselling. Probably the most prolific source of evidence of the process at work come from the use of video (CCTV – closed circuit television as it was called) to shape or modify novice teachers in what was called "microteaching". (Allen & Ryan, 1969) Similarly, self-confrontation is the process at work while students use performance aids such as concept maps and learning logs. Experience with such performance aids did suggest that the process of self-confrontation caused "cognitive dissonance" (Festinger, 1957). This felt state of cognitive uncertainty or puzzlement is important in concept mapping. The "dissonance" between the external and the internal representations has to be resolved and it is in this resolution that new concept labels are created and relationships made and edited. This process is complex and uses a lot of working memory capacity. In fact working memory is inadequate to handle such disambiguation. There is ample evidence from different sources that working memory is a constraint in disambiguation (Stenning, et al 1995). The brain has to supplement its operation or working area and this is achieved through off-loading.

7.4. OFF-LOADING

If one accepts the common view that there are two types of memory – short term and long term (e.g. James, 1890; Baddeley, 1992), then it is reasonable to suppose that the capacity of the short term memory registers is a limiting factor on the immediate processing of information. In an earlier paper, the present author presented an explanation of the process of concept mapping in terms of a learning arena. This arena is the concept map. At the heart of the argument was the observation that the limited capacity of working memory registers lead to what Sweller called "off-loading" (Sewller & Chaldler, 1991).

McAleese saw the visualisation that the concept map afforded as providing an adjunct to the working memory. The concept map was a performance aid – a learning arena where the learner could " ..interpret and organise their personal knowledge…"(Jonassen, et al 1998). Given the way an individual processes a concept map, or compares what is known to what is recorded in a map (see below), the limited capacity of working memory has to be taken into account.   Different views exist on the exact capacity of STM. It matters little if there are 7 "registers" (Miller, 1956) or 3 "registers" (see Broadbent, 1975).   An extension of this capacity through off-loading (Sweller, & Chaldler, 1991) is likely to provide more complex processing and enable an individual to more effectively disambiguate complex ideas (see, McAleese, 1994; 1998) Information processing depends on the ability of some function of the brain to make comparisons or top hold "in view" a complex idea or model while it is operated on. Individual concepts act as chunks (see Miller, 1956). In Figure 1, the student is chunking complex ideas with long concept labels. For example { Rejected by the Lords, Liberal Party fell from power}. This chunk - in terms of understandings – is associated with {1st laws limiting alcohol proposed}. In order for an individual to hold significant areas of this map in short term memory, two effects must occur. First the individual uses a short hand label for complex ideas – for example { Rejected by the Lords, Liberal Party fell from power}. This chunk is a sign for a more detailed cognitive model. Second, the map is used by the individual to provide a display or representation arena where many such chunks can be operated on (see McAleese, 1994)

7.5.   THE   PROCESS   OF   CONCEPT MAPPING

There have been very few attempts to explain the process of constructing and maintaining a concept map.   [14] The creation and modification to a concept map is clearly a process that involves a number of discrete but inter-dependent steps. (see Figure 1) There is a sub-process of initial node and/ or relationship creation. This is followed by a number of sub-process including the modification of the initial map created with further additions and deletions. In order to clarify the process the author created a series of maps based on reading a textbook. [15] Figures 2 and 3 show two maps. [16]   Figure 2 is a snapshot of the initial map. It consists of   33 nodes (concept labels) and 28 directed arcs or Relationships. There are two main clusters – one comprising 6 nodes; the other comprising 26 nodes and a singleton {Cybernetics}. The main cluster is a composite of two sub-clusters – with {Perception} related to {Mental Models} The starting node { Conceptual Structures} is differentiated from the others with a different iconic representation – an ellipse as opposed to rectangle. .Figure 3 shows the state of the map after the author had added new nodes; made additional Relationships (labelled and unlabelled) and adjusted the nodes to show better the relative semantic similarities of the concepts and to disambiguate nodes and relationships – in terms of spatial layout. Figure 3 has 50 nodes; with 51 relationships (directed arcs) . Of these relationships 13 are labelled. The map comprises two clusters of nodes – the smaller (centred around {Cybernetics} comprises of 9 nodes – all added after the initial creation (Figure 2). There are at least three different mapping situations that arise. The different situations comprise:

▪ The recall of previously learned and known ideas – the individual thinking "What do I know about {x}? Typically during revision or as a part of learning new material.

- The recording of new ideas as a result of some learning situation – e.g. reading a book , listening in a lecture - the individual making notes in a Concept Map as a study aid;

- An individual "thinking about" some already known idea or ideas in response to some event or situation.

7.5.1.   *Phases in the Construction of a Concept Map*

The process of map creation starts with an individual intending to make sense of something that is knowable. The process of map creation and maintenance based on this example falls into the following ten phases:

1. Creation of "seed" node; a map must start with one "concept". The person constructing the map – may have a series of ideas but the first is critical. It - along with any other first order concepts trigger the subsequent cascade.

2. Addition of associated nodes using a "rapid fire" technique of recording the remaining first order of associated nodes; in addition there may be the addition of relationships.

3. The creation of new clusters of nodes with additional "seed" nodes; nodes and relationships may be typed. [17] Certain relationships will require a particular type of node – for example {fermentation} {causes} {carbon dioxide}. The {causes} relationship will trigger a particular type of related concept.

4. The addition of singleton nodes; such node may later be included in clusters when they have relationships added.

5. The creation of relationships between existing clusters or singleton nodes;

6. The labelling   and typing of relationships;

7. The deletion of nodes and/ or relationships;

8. The editing of concept labels, types and relationship labels;

9. The editing of concept icons; this may involve a global typing – for example – all the nodes that refer to authors may be a particular icon type imposed.

10. The movement of nodes or clusters of nodes to accommodate tacit or explicit semantic rules; this may involve using semantic similarity to cluster node and to place apart nodes of different types.

These stages form a multiple-recursive progression. Step 1 is not repeated. The time taken for this process was about 30 minutes. What cognitive explanation can there be for these events?. If one starts with a static description of the dynamic process the following phases can be suggested. [18] In general individuals tend to create nodes first; then make relationships; followed by labelling of relationships and typing of nodes.

(a) The Concept Map - comprising *n* {Concept Labels} and *m* [Relationships/ Arcs] displayed on the computer monitor [19] gives rise to a sensory image (S). [20] The image is a representation of the Concept Map (M). The image is created through sensory input channels – e.g. the eyes and activates specialised areas of the visual cortex. [21][22] [23]

(b) An Associative Comparitor [24] finds one or more Percepts (P_1 to P_n) from a cognitive store that match some or all of S. [25]

(c) An Assembler combines the retrieved Percepts to form a Working Model or Cognitive Graph that approximates to S. For each Percept in the Working Model – there is an isomorphic Concept Label C_1 to C_n. The creation of the Working Model is a transient stage. The Cognitive Graph is the stored understanding of any one idea.

(d) If such a Working Model can be constructed using the Percepts, the Map (M) is explained by the Working Model and by definition makes sense to the individual. This state leaves the individual "happy" or "content" that they can make sense of the idea using the map M.

(e) If the Working Model is in any way deficient or can not adequately explain the Map (M), the individual either shifts their attention to an other area of the Map – and steps a to d re-occur, or the individual retrieves an existing Cognitive Model of one or more Concepts. These Models lead to the creation of a new Concept label or relationship through interaction with the computer application.

(f) New Concept labels or relationships are created. This step is in response to the ambiguity created when the Working Model is not adequate to explain the sensory image (S). This step creates new nodes and/ or relationships.

7.6. MIRROR, ASSISTANT OR MASTER ??

A plausible but still tentative framework has been provided for the process involved in the creation and maintenance of concept maps. What are the implications for learning and instructional design? A tension has been implicit in the framework suggested. On one hand the map is an assistant providing an extension to cognitive capacity. It is in part a mirror – showing the learner what it is that they know. Allowing the individual to be aware of the relations within and between cognitive models of concepts. As a mirror the map would only reflect – externally – what is and how it is known. It seems most unlikely that a map is such a static device. No one who has used a concept map would doubt that their understanding of what ever it was they mapped remained totally unchanged. There is some interaction between the external representation and the internal understanding. The experience of the

map leads to reflection – this reflection is generalised and tested against subsequent experiences (c.f. Kolb, 1984) With off-loading the learner is able to process complex ideas in a that would not be possible with out its functionality.   The assistant role is very important yet it brings with it an external Locus of Control. It may be that representation in terms of a formalism determines what can be known. A number of aspects to this claim should be noted. First, the metaphor itself determines the inter-relatedness of concepts. Second, the learner is predisposed to make relationships between unconnected concepts.

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new technologies for higher
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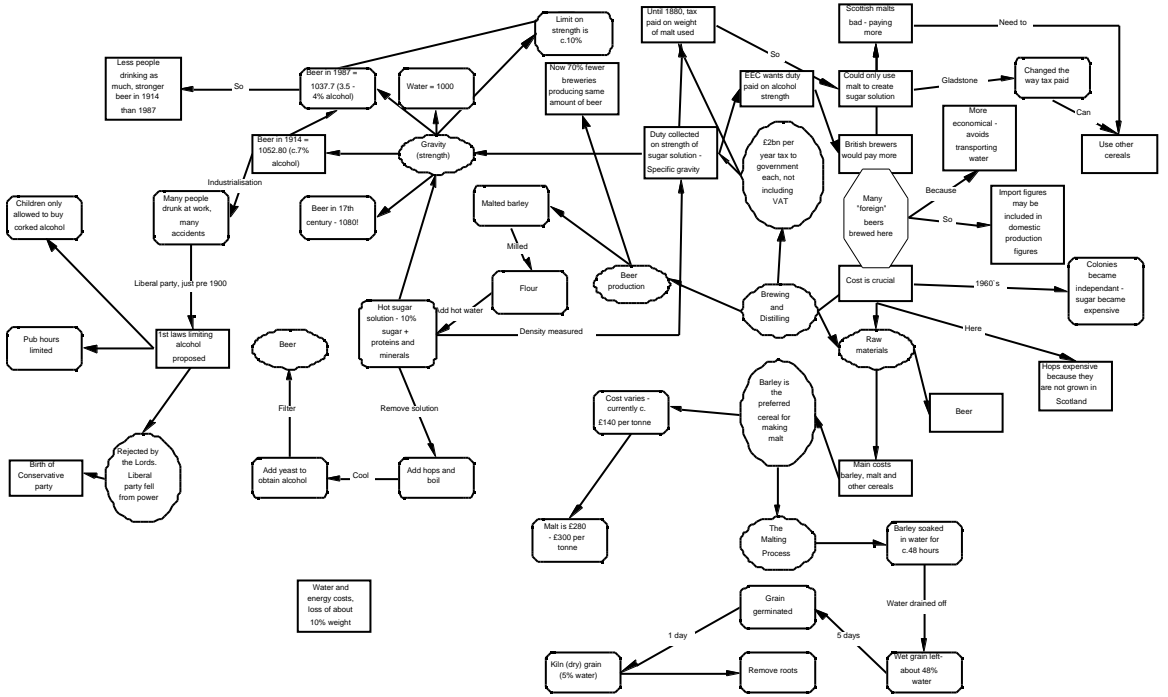
Figure 1: Concept Map Drawn By University Student as Study Aid

Recognition

Working Registers

Short Trem Memory

Long Trem Memory

Recall

Recognition

Eidetic Images

Icon

Symbol

Referent

Mental Models

Rules of Syntax and Semantics

Intensions

Associationism

Working Model(s)

Percepts

Associative Comparitor

Stimulus Constancty

Conceptual Structures

Assembler

Perception

Motor Mechanisms

Extensions

Available Percepts

CONCEPT

Conceptual Graphs

Sensory Icons

Distributed Storage

Schemata

Semantic Networks

Top-Down Match

Assocuative Retrieval

Cybernetics

Figure 2: "Initial" Concept Map Created by Author – immediately after reading Sowa (1983)

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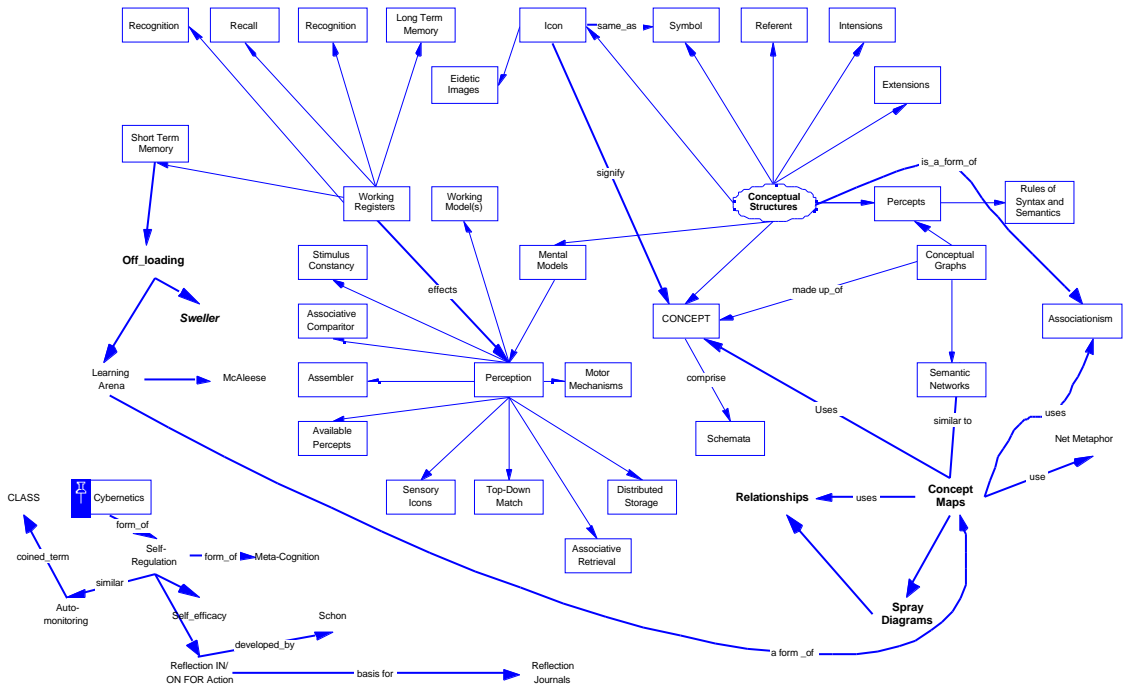
Figure 3: Concept Map Created by the Author – after adding nodes, relationships etc.
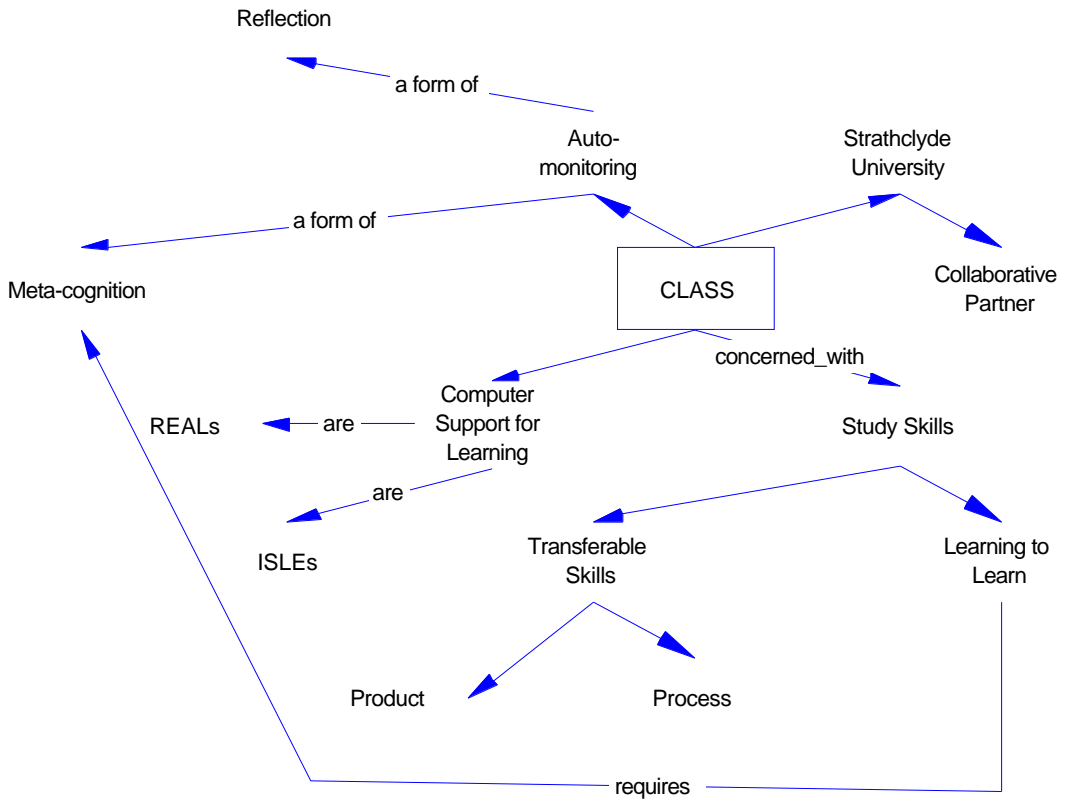
Figure 4: "Daughter" map for {CLASS}
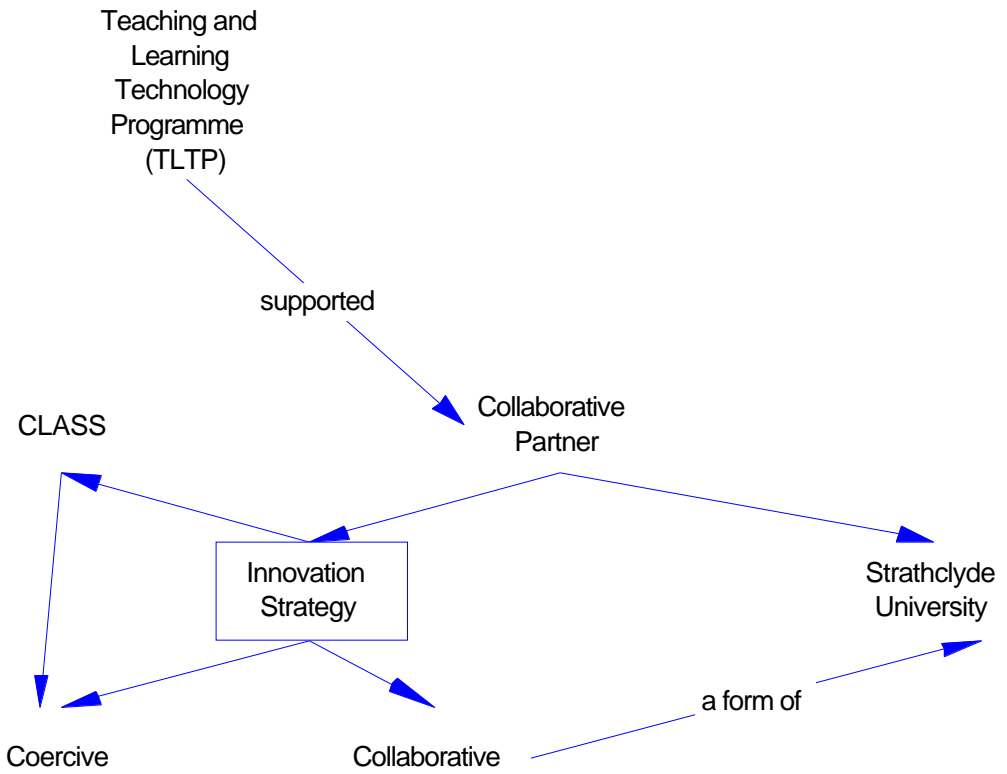
Figure 5: "Daughter" map for {Innovation Strategy}

Endnotes

1   It is tempting to use the micro analysis of neural nets as conceived in cybernetics to provide an isomorphic explanation of concept maps. The temptation should be resisted. While there is ample evidence of message passing and activation ripples in neural activity – similar to associationism in concept mapping – there is no claim made in this paper that concept maps are isomorphic with neural activity. The principal reason is the granularity of the entities. Concept maps involve Concepts and Percepts – which are magnitudes of complexity greater than the activation of one neural center and the co-activation of adjacent nodes.

2   Each of these citations uses different assumptions about the nature of concept maps and the name used – e.g. Mind Maps (Buzan)

3   The convention of placing within curly brackets {} the concept label or the relationship will be followed. The brackets represents a non-empty set – with minimally one member – e.g. {c a t} or {causes}

4   The question of what exists "at" a node or by a relationship is complex. In practice the sign represented signifies a cognitive model. So, {c a t } signifies all the known characteristics and attributes for the family pet; similarly {causes} signifies a state of effect of one agent on another. {causes} is a sign or label for a model of "causality" according to an individual. Thus {cat} {causes} {Chaos} is a meaningful belief/ understanding by an individual – represented in terms of two nodes and one directed relationship. This means that nodes and relationships comprise signs that signify concept models.

5   "Virtual" signifies a symbolic non-real space. Concepts do not exist per se in the human brain.. We understand their operation and significance in terms of their existence as entities. Such entities can be represented in a symbolic system - a "virtual space".

6   "De-compression" is an important idea. Its definition is slightly counter intuitive. When a concept (concept label) is de-compressed it is expanded to show all other concepts/ concept labels that it comprises. In some software that supports mapping this is achieved by creating a "family" of nodes – each node having a parent (compressed) form and n-generations of children (de-compressed) nodes. However, in available commercial software (e.g. Inspiration), links are nor possible from leaf nodes of "children-maps" to leaf nodes in "parent-maps". In reality, such relationships exist.

7   The term "structural knowledge" is an extension to the classification "procedural" and "declarative".

8   Inspiration is a commercial application that is designed to be used in a number of brain-storming and outlining situations. [Inspiration Software   URL: www.inspiration.com/techsupport.html]

9   This map is the result of the following scenario.
a) Students were taught to produce patterned notes in the form of concept maps using Inspiration.
b) A class of students were given a lecture on the Brewing Industry in the UK as part of a study Skills course – where they had to demonstrate their competence in analysing data and writing reports.
c) The students were asked to make notes during the lecture and to submit a patterned note-style concept map using Inspiration after the lecture. This map is a map submitted by one student.

10 The temporal nature of concept maps is not recorded in most literature. The temptation is to see a map as a fixed or static product. Rather it is a snap shot of a process.

11 The terms "reflection IN" and reflection ON" - action, were coined by Donald Schön. When individual reflect ON action they consider events that have occurred; when they reflect IN action,

nuwe... ifr. v. irz. 98
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they consider events as they occur. (Schön, 1983;1988)

12   The present author has developed a concept mapping program that allows for learners to represent formal semantic structures such as an "argument". In this specialised or constrained form of map, the nodes are typed allowing certain pre-defined categories of concepts to be represented – for example: Claim, Warrant, Backing, Evidence etc. This work is based on formal communication structures provided by Kuhn (1992); and Streitz & Hanneman (1990). It is influenced by Toulmin (1964). See also Ranney, et al (1992) for an approach to mapping based on Evidence and Theory.

13   Characteristics of "Locus of Control" will be : learners can anticipate difficulties and take action to avoid them; learners believe that their plans will lead to outcomes they can envisage; are that mistakes are controllable. (See Scale(s) used to measure LoC, such as Craig et al (1984).

14   See Batley, S, & McAleese, R (1986) Concept Maps: A Bibliography University Teaching Centre, Aberdeen University (Mimeo) ; & Lanzing, J W A (1997) Concept Mapping Bibliography [URL: www.to.utwente.nl/user/ism/lanzing/cm_bibli.htm]

15   The techniques used was as follows:
i A book was selected and read for about two hours. The book (Sowa, J F (1983)
ii Conceptual Structures: information processing in mind and machine, Addison Wesley, was chosen as it was related to the topic of this paper and the author knew he wanted to read it or sections of it again for that purpose
iii After reading the book for two hours, the author used the computer application Inspiration on a PC to make the concept maps. The author is familiar with the application and used the following technique:
iv Using a "rapid fire" facility, as many nodes as possible were created.

v The map (Inspiration file) was saved from time to time and snap shot screen snaps were created in BMP format.
vi The concept labels were spell checked and a number of alterations made. No attempt was made during "rapid fire" node addition to be precise in spelling of the labels.

16   The maps in Figures 2 and 3 are snapshots. The process is dynamic. However Figure 2 is an initial stage where the majority of nodes associated with the source text are "dumped". The stage of Figure 2 is an end point – used for this paper. The can be no final end point as logical the author could re-visit the Figure 2 map after some time and made additional alterations.

17   A typed node is a node of a particular category of concept. For example "counter-example". Such a node may have a unique icon signifying its type.

18   This explanation draws on the work of Sowa (1983); Sweller & Chaldler (1991) and McAleese (1994).

19   There is no reason to believe that paper and pencil concept maps - e.g. Buzan-style are significantly different. The creation of hand drawn maps may cause some slowing down of the cognitive processing but otherwise the situations are comparable.

20   Clearly there are a series of sensory images but for the sake of clarity. It can be assumed that there are minimal differences between adjacent images S_I and S_{I+1}. The subject will be aware of the incremental creation of labels as the letters appear on the screen – however, for simplicity we will assume complete labels and complete nodes and relationships. Rainer et al (1998) suggest that focal attention has a significant effect on the ability of short term memory to make use of information. In deed they suggest - in animal studies - that ".. working memory directs attention..". The significance of this for concept mapping is still not clear.

21   Different areas of the visual cortex must be activated. There is no direct evidence using Concept Maps with regard to the exact areas. However, it is likely to be the pre-frontal cortex. (see, Rainer et al, 1998)

22   The individual will focus on selective areas of the Map. For example – in Figure 2, the author might "look at" {Short Term Memory}. The resultant creation of the new node {Off-loading} is a result of steps a to e in the text above. In other words the individual will selectively examine the Map – scanning the nodes and relationships in a systematic fashion. Eye saccades will determine the extent and details of that the learner perceives and processes. (see, for example, Hoffman, J E & Subramaniam, B, 1995)

23   The sensory image is created in a visual buffer. The capacity of this buffer is limited although manipulation of images is possible. Such images comprise Percepts and Concepts which give rise to the image. It is the limitation in size of the visual buffer that gives rise to the off-loading of thinking (see, Sweller & Chaldler, 1991) in to what the present author has called the learning arena (McAleese, 1994).

24   See Sowa (1983) p70.

25   The "working area" is taken to be the Working Memory. It is within these registers that the operations on the elements of the map and the existing models occur. There is evidence that the capacity of visual working memory is enhanced by "chunking" or integration of individual elements. (see, Luck, & Vogel, 1997)

8. DESIGNING AND INTEGRATING TECHNOLOGY RICH CURRICULA
INVITED PAPER

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Abstract - **As knowledge bases become more complex, strategies designed to extract meaningful information, or to engage in meaningful interactions with the knowledge base become more elaborate. Thinking of each student as an independent learner who must learn the same concepts and processes as the next student limits the educational strategies available to the teacher, the learner, and the institution itself. This paper describes a conceptual model for integrating curricular issues which attempts to address the demands of an exponentially expanding sphere of knowledge in every domain. Students are viewed as consumers, producers, synthesizers, and evaluators of knowledge.**

8.1. BACKGROUND

Most college programs, and college methods courses in particular, are based on instruction in the *use* of relevant knowledge of content and pedagogy. Presumably, this is due to two factors: (1) the sources for content material were traditionally limited to course texts or supplemental reading material and (2) pedagogical models focused primarily on instruction involving direct interaction between students and teachers.

This article promotes a model for course development which redefines ways of knowing in order to make the acquisition, processing, synthesis and evaluation of new information relevant to the student. The model attempts to overcome problems related to conceptually fragmented, unfocused lessons based on the memorization of isolated facts (McDevitt, Heikkinen, Alcorn, Ambrosio, and Gardner,

1993). In addition, the model provides a much more elaborate view of communicating and reporting to peers on both individual and collaborative levels. The model has been used effectively in two undergraduate classes, and one graduate class at the University of Florida.

This model is based on the assumption that integration principles operate at systemic, curricular, and instructional levels. The curricular orientation of the model promotes seamless interdisciplinary activity through the design of conceptually focused activities which are based on non-discipline centered problem solving strategies. At the instructional level, concepts and topics will be addressed from multiple perspectives, but along lines not always related to specific disciplines. Taken together, the activities provide strong contextual framework for student investigation (see [http://www.coe.ufl.edu/Courses/EdTech/Designing/TechRich.html] for previously assigned modules). For example, the study of DNA might include collaborative group efforts in each of the following areas: the properties and 3-dimensional representation of a double-helix, DNA fingerprinting (interpretation and use in the forensic sciences), historical interests (the research of Watson and Crick, for example), the Human Genome Project, and social and ethical issues related to genetic screening and treatment. Each group must make a comprehensive report to the class.

As each group reports its findings, students become familiar with not only the larger issues associated with DNA, thus helping them become more informed decision makers, but also with the complexity of the particular branch of study under

investigation. While at least one level of abstraction away from traditional views of diversity in education, the model attempts to incorporate a diversity of ideas into each experience.

8.2. DEVELOPING INTEGRATED MODULES

In this model, a course module is composed of a number of activities designed to address a specific perspective related to the core concept. Ideally, cooperative groups are established and all activities are done simultaneously, although it is conceivable that the activities could be addressed sequentially in a teacher directed environment. In cooperative mode, the number of activities necessary is a function of group size and the number of students in the class. In other words, in a class of twenty-four, six activities would be created if each group contained four members.

Course modules (sets of experiential activities) should be suitable to a wide variety of pedagogical styles, and although it is sometimes appropriate to incorporate diverse styles into teaching methodology, these activities intentionally exhibit a bias towards collaborative group work to reflect activity in the business environment. Moreover, students working in groups are simultaneously users, producers, interpreters and evaluators. Students will become familiar with groupwork strategies for heterogeneous classrooms (Cohen, 94) on two levels: (1) understanding concepts, solving problems, using oral language skills, and (2) solving complex problems, developing points of view, interpreting investigations, and constructing complete projects. All activities should be examined on a process level and a pedagogical level as part of the course content. In other words, students should review the processes and teaching strategies used by their instructors at a cognitive and meta-cognitive level.

Each course module can contain a wide variety of activities. Students may be assigned research papers (and presentations), science experiments and other hands-on activities, or activities involving interactive tools such as the GeometerÆs Sketchpad, A.D.A.M. (Animated Dissection of Anatomy for Medicine), or Exploring the Nardoo River (a simulated investigation of an ecosystem). Consider, for example, using the Exploring the Nardoo River simulation, which contains 13 science investigations into the environment. The program allows students to gather data by searching through elaborate files in a research center, by visiting sites and taking probe readings, by listening to radio and television broadcasts on related matters (which include interviews with people living in the region), by studying plant and animal life in the region under investigation, and by running simulations in a (simulated) science laboratory. By designing other modules around work with the Nardoo simulation, such as taking real water samples locally, visiting the Project G.L.O.B.E. on the internet, doing qualitative analysis on water samples, or reviewing baseline data on water in the region, students will develop a real world link to their studies. Reports contain real data, and involve persuasive writing and design which uses statistics, charting, and other visual perspectives to make a case. Hypermedia becomes a critical thinking tool, and students learn to use appropriate information channels to communicate with peers.

8.3. TRANSFORMING THE CURRICULUM

In order to transform the curriculum, and to model the transformation for students, experiential activities should be tied to global academic processes and themes such as those found in the Mathematics, Social Studies and Science Standards. In other words, each activity should address specific process themes such as interpreting data,

inferring, predicting, operationally defining, etc. as well as content themes such as pattern recognition, social conflict, social organizations, tradeoffs and so on. In education methods courses, the themes and standards frameworks used in each lesson should be made explicit, in order to help students learn to identify and apply the big ideas associated with various disciplines and commonalities between the disciplines.

When designing activities it is helpful to think conceptually, designing activities which address issues relating to history, drama (the people involved), mechanics (calculations, or experimental procedures), decision-making, real-time data collection, interactions involving the concept or its dataset, and simulations of real or theoretical aspects of the concept. Clearly, content-specific perspectives may also be developed. In addition, powerful electronic search engines may be used to locate lessons related to content and process themes and national standards. Science Helper, Culture and Technology, Mathfinder (see http://www.learningteam.org for information on these tools) and a variety of web pages offer curricularists thousands of lessons on a variety of topics.

Education students should be made aware of the decisions related to development of the modules and activities with which they are working. Moreover, students in methods courses may be asked to create course modules of their own. During this process, they should be encouraged to use electronic tools to locate activities and experiences.

8.4. NEW FORMS OF COMMUNICATION

The role of media in the teaching and learning process is promoted to an explicit level in the design of the integrated modules. Understanding characteristics of particular media and being able to make appropriate media choices will be designed outcomes in the activities. In completing the activities,

students use technological tools to organize, storyboard, compose, build prototypes, and report. The integration of appropriate media elements into student compositions is assumed. In other words, the students will be expected to use text, graphics, audio, digital video, charts, and animations to gain support for their ideas.

Communication with peers, colleagues, and larger communities will be an important aspect of 21st century work and play. Students should be familiar with various communications strategies and shortcomings associated with storytelling, argumentative discourse, fleeting correspondence, multicultural communication, technical communication, and communication through visual, aural, and performing arts. Each module should contain activities which emphasize building a communication infrastructure in work groups and beyond, with particular attention to reporting and presentation. Reporting genres such as Explanation, Procedure, Exposition, Discussion, Narrative, Recount, and Review can be used, and the review of these genres should be a component of the course. Similarly, different styles of presentations (written, verbal, visual, multimedia, mixed media) should be reviewed for appropriateness in various situations. Technical writing styles should be applied whenever possible and promoted as a necessary part of a K-12 curriculum, even though it is often absent in American schools today. Finally, group processes should be discussed as part of the module, and goals related to individual, group, and class knowledge acquisition should take place (Johnson & Johnson, 1994).

8.5. CLOSING REMARKS

Illustrations involving misconceptions or inadequacies in our thinking about education are everywhere, from dysfunctional ideas about lesson plans to misguided beliefs about

the internet. As we search for individual
solutions to these complex problems, we find
broader ways of interpreting our problems,
and consequently, more questions. If
students are not all expected to learn the
same ideas from a sole source, then what
tools will they need to become independent
learners? How will they learn? What
systemic changes in the learning process will
take place? What kinds of information
channels are most appropriate for
dissemination of a particular content? How
will logical arguments be put forth in a way
that can be understood by the masses? Can
interactivity provide us with more powerful
learning tools? Will simulations give
learners the context-sensitive environments
they need to develop *real* problem solving
skills? These questions are operationalized
in the design and implementation of
integrated learning modules such as those
discussed in this article.

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9. RUNNING HEAD: REALS AND DISTRIBUTED LEARNING REAL STRATEGIES AND DISTRIBUTED LEARNING

INVITED PAPER

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Abstract -Rich environments for active learning (REALs) are student-centered learning environments that rely on authentic contexts, collaboration, generative learning, and reflection. They are highly interactive depending on a great deal of intellectual probing by the teacher/facilitator and collaboration among students to be successful. Can REALs (e.g., problem-based learning, anchored instruction, intentional learning, and others) be replicated using distributed learning technologies such as the world wide web? Many distributed learning programs rely on information presentation to replicate traditional classroom environments. The purpose of this paper is to examine REAL strategies and their applicability in distributed learning environments (DL). In the process, the paper defines REALs and distributed learning and suggests opportunities for additional research.

9.1. REAL STRATEGIES AND DISTRIBUTED LEARNING

9.1.1. *Expectations and Change*

Changing global economic circumstances and increasingly complex societal needs are placing greater and greater pressure on education systems to produce learners who can apply knowledge and skills in new domains and in changing situations. Both public and private institutions expect and demand employees who can think critically and solve a range of problems, who can move easily from one task to another, and who can work efficiently and effectively in team situations; yet, they claim that those people are difficult to find. Educators, to a large extent, agree that students must learn to solve problems and think independently (Bransford, Sherwood, Hasselbring, Kinzer & Williams, 1990; Feuerstein, 1979; Linn, 1986; Mann, 1979; Resnick & Klopfer, 1989; Segal, Chipman & Glaser, 1985). Their challenge is to utilize strategies that teach content in ways that also help to

develop thinking, problem-solving, metacognitive, and life-long learning skills (Bransford et al., 1990; Savery & Duffy, 1994) without becoming overwhelmed by the notion that students "need to know stuff" or the political demands for "good test scores."

The challenge to meet the needs of society for creative, problem-solving individuals is further complicated by the omnipresent microprocessor. Computers have moved from task specific devices (e.g., word processors, number crunchers, and data managers) to gateways to the world of information (e.g., the world wide web, data bases, search engines, and collaborative tools). Most of us would acknowledge that computers have changed the ways we work, play, learn, and teach. Though that is significant in and of itself, the greater effect is that computers have changed our *expectations* about how we work, play, learn, and teach.

It is this notion of changed expectations on the parts of both employers and learners that is having a profound impact on education. Employers want creative individuals who know how to use information — not just find it. Learners want immediate access to information and educational opportunities. Going to the library is an inconvenience. The traditional school year and scheduled on-campus classes are cumbersome and force people to wait when what they want is just-in-time learning. As educators we are in an awkward place between the two groups. On the one hand we are expected to produce people with higher level thinking skills able to transfer their skills and knowledge to a wide variety of situations. On the other hand we are expected to offer classes on demand in highly individualized ways. At times these expectations are in conflict.

Two broad educational trends illustrate this conflict: the move toward increasing use of constructivist strategies for rich environments for active learning (REALs)

and the move toward increasing use of distributed learning technologies. In this article, we attempt to ease, though not reconcile, the tension between these two trends by describing ways that REALs can be part of distributed learning environments. We begin with a brief discussion of distributed learning and then move on with a description of ways that REAL strategies can be combined with distributed learning methods.

9.1.2. *Characteristics of Distributed Learning*

Distance education changes the learning relationship from the common, centralized school model to a more decentralized, flexible model. It also reverses social dynamics by bringing school to students, rather than students to school. (Sherry, 1995, p. 359)

Whether called distributed learning or distance education, educational programs offered in this format have several common elements: 1) teacher and student are separated in space and/or time (Perraton, 1988); 2) students take more responsibility and initiative for their learning (Jonassen, 1992); and 3) communication among instructor and students is mediated by technology (Garrison & Shale, 1987; Sherry, 1995). Though it may seem like quibbling over semantic differences, we contend that the notion of "distance education" is limiting from a historical perspective and that "distributed learning" is closer to what we are trying to achieve.

The original concept of distance learning developed as a way to reach learners at distant sites with radio, postal correspondence, television, telephone, video tape and so on. Often, the only means of further education is via the distance learning media for students in the program. However, the original notion of distance learning has been broadened in its application. Today, the

use of modern distance computer-based technologies including the world wide web and electronic mail (e-mail) has moved onto the traditional campus. Students who have access to traditional campus instruction now expect to be able to use distance technologies, even though distance is not a barrier — at least in its traditional sense. Instead, their learning is now "distributed" between home and campus. What is more important is the evolution of a new paradigm involving traditional and newer distance technologies. Wagschal (1997, p. 5) states, "Already, the World Wide Web and other aspects of the Internet are robust enough to enable a new paradigm to replace our previous conceptions of a University as a geographical place where students gather to learn at the feet of their gifted and knowledgeable professors." These and other primary features that distinguish distance versus distributed learning follow.

9.1.2.1.   Changing Paradigm

Historically, *distance learning* models viewed learning as the passive acquisition or absorption of an established body of knowledge. Distance learning strategies used media to transmit information through the air or in the mail. In this paradigm, the teacher's role is to "acquire formal knowledge, find efficient ways of sharing it, and determine whether the pupils have learned what was taught" (Cuban, 1993, p. 248). Instruction, then, is a process of transmission or delivery.

The newer view of *distributed learning* views learning and instruction more flexibly incorporating a greater variety of instructional support. Distributed learning tends to follow a student-centered learning paradigm. This paradigm holds that learners acquire knowledge through a process of construction based on personal experience. Students take an active role in determining the time and place of their instruction. Norman and Maxwell (1998) describe distributed environments as more instructionally flexible than traditional

distance learning programs using a variety of technologies including fax, prerecorded video, e-mail, web pages, and face-to-face classes.

9.1.2.2.   Expanded Notion of Distance

In the past, distance was distance in terms of space. Now, distance has a broader meaning referring to obstacles related to time, space, and the ability to contact other students and teachers as well as psychological distance. Students today want greater flexibility, even when on campus, in when they can take classes, contact teachers, or work with other students. They have busy lives, live in congested cities, care for families, and often work more than 40 hours a week. They want their learning distributed among home, campus, and work (Hardy & Boaz, 1997). Wagner (1996, p. 11) states:

"Although many aspects of traditionally delivered instruction will remain as an option, particularly for younger students on residential campuses, other students will have the opportunity to acquire information when and where the desire, with the option to experience it multiple times. This will be instruction on demand, and will be time-and-place independent."

9.1.2.3.   Instructional Variety for Differing Student Needs

Traditional distance learning programs dealt with fairly static, school-based content. The instructional strategies tried to replicate what happens in traditional classrooms with lectures, activities, question and answers, and teacher responses. Today students demand content tailored to their personal and work needs. Content, in a distributed environment, should be anchored in a realistic situation or problem. The instructional strategies attempt to implement the characteristics of REALs (described below), trying to make learning more authentic and relevant to students who are willing to take initiative and assume responsibility for their learning. In this kind of instruction, the content can change

depending on the needs of the problem and situation.

9.1.2.4. Multiple Media in Varied Delivery Contexts

Distance learning programs tend to focus on one medium to deliver content such as radio, compressed video, television, or printed materials sent via post. A distributed environment may integrate many media including on campus classes, e-mail, video, still pictures, teleconferences, web pages, and so on. DL programs have to be much more sensitive to individual student needs with both content and learning styles and, therefore, must be more flexible in the media used. DL environments also depend much more on interactive communication than the transmission of information.

9.1.2.5. DL Conclusion

As described, the distributed learning model that mixes on-site and electronic strategies has pedagogical implications:

> The theoretical basis on which instructional models is based affects not only the way in which information is communicated to the student, but also the way in which the student makes sense and constructs new knowledge from the information which is presented. (Sherry, 1995, p. 340)

We will discuss the relationship between distributed learning and REALs in the remainder of the paper.

9.2. REALS AND DISTRIBUTED LEARNING

Rich environments for active learning are comprehensive instructional systems that engage students in dynamic, authentic learning activities that increase their control and responsibility over the learning process while they learn problem-solving and collaborative skills and content (Dunlap & Grabinger, 1992; Grabinger & Dulap, 1996; Grabinger & Dunlap, 1994a; Grabinger & Dunlap, 1994b; Grabinger, Dunlap & Heath, 1993). REALs are based on a constructivist view of learning, which holds that knowledge is acquired through "a process of subjective construction on the part of the experiencing organism rather than a discovering of ontological reality" (von Glasersfeld, 1979, p. 109). This is then, by definition, a student-centered process. It is also a social process of negotiation, conversation, testing, and challenging (Bauersfeld, 1995; Cobb, 1994). Specifically, the attributes of REALs:

- encourage the growth of student responsibility, initiative, decision making, and intentional learning;
- utilize dynamic, interdisciplinary, generative learning activities that promote high level thinking processes (i.e., analysis, synthesis, problem solving, experimentation, creativity, and examination of topics from multiple perspectives) to help students integrate new knowledge with old knowledge and thereby create rich and complex knowledge structures; and,
- promote study and investigation within authentic (i.e., realistic, meaningful, relevant, complex, and information-rich) contexts;
- cultivate an atmosphere of knowledge building learning communities that utilize collaborative learning among students and teachers (Collins, 1995);
- embed opportunities to reflect on the learning process as well as content acquired to promote both learning and metacognitive skill development.

The distributed learning concept tries to follow this student-centered view of learning. Distributed learning students take

an active role in determining the time and place of their instruction. DL programs may use a combination of delivery methods and technologies. DL programs and REALs place a much greater premium on interaction than on transmission. In our view, then, this new model of distributed learning incorporates the new pedagogical practices represented by REALs. How will it be done? In the remainder of this paper we examine the relationship between the attributes of REALs and distributed learning.

9.2.1. *Intentional Learning*

REALs create intentional learners. Students engaged in intentional learning are purposeful, effortful, self-regulated, and active learners (Palincsar & Klenk, 1992; Scardamalia & Bereiter, 1985; Scardamalia & Bereiter, 1991; Scardamalia & Bereiter, 1997; Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989). REALs attempt to give students more executive control over their learning to enable them to take more ownership, find more relevance, and learn lifelong learning skills. "Creating autonomous, lifelong learners, REALs…teach students to manage their own learning: identify their learning needs, set learning objectives, select and employ learning strategies, identify and use appropriate resources, and assess their overall process" (Grabinger, Dunlap & Duffield, 1997, p. 9). To be intentional learners, students must identify learning deficiencies and strengths, make and implement plans, develop metacognitive awareness, and revise those plans and actions based on that awareness. To teach for intentional learning means to cultivate those general abilities that make it possible to become independent, lifelong learners (Palincsar, 1990).

Research (Scardamalia & Bereiter, 1991) indicates that students can assess what they know and don't know and learn to ask questions to guide their knowledge building, thus assuming a "higher level of agency" and more ownership for their learning. While it is the students' responsibility to "identify their own deficiencies, to ask questions about their knowledge base, and to select and manage their learning activities" (Grabinger et al., 1997, p. 7), designers of a web-based course most provide the student with the skills and tools to be successful. Support, then for intentional learning begins with fundamental operational behaviors and moves on to learning and metacognitive strategies.

9.2.1.1. *Intentional Learning and Distributed Learning*

9.2.1.1.1. Support for Transition to DL

"Students need support and direction to enable them to make the transition from traditional classroom environment to self-directed learning — particularly tools to help them monitor their progress and obtain timely feedback on their activities" (Sherry, 1995, p.352). Hardy and Boaz (1997, p. 1) define student development as the process of preparing "the student for a distance education experience, beyond the technical orientation." This orientation needs to include learning to operate within the DL environment and refining metacognitive skills. To be successful, students will "need guidance in putting information together, reaching their tutors, and completing and submitting assignments" (Sherry, 1995, p.352).

DL students need to know what is expected of them in the DL environment. They must be self-disciplined and self-motivated, be able to work independently, and persevere. DL students must be aware of the institution's and the instructor's protocol. For example, when is it appropriate to send a message to just the instructor rather than the whole group? How long should communications be? How often does one need to communicate? Can a person send too many messages? When are messages expected?

Instructors need to be aware of their skill level with the technology and they must be willing to share this with their students. Technical support must be readily available for both students and instructors. Students need to know how to interrupt or correct instructors. When problems are brought to the instructor's attention he or she must make corrections immediately (Hardy & Boaz, 1997).

9.2.1.1.2. Setting Goals

An important part of operating intentionally is the ability to set realistic and appropriate goals. Since a DL environment relies heavily on independent initiative and study, these goals need to be meaningful to the student. Part of setting goals is the ability of students to identify what they know and what they do not know. Scardamalia and Bereiter (1991) were able to teach fifth and sixth grade children to do this. Their computer-supported intentional learning environment (CSILE) provided technological support for classroom students to identify their learning needs and set goals. A DL program does not need to create a program as sophisticated as Scardamalia and Bereiters' CSILE, however faculty do need to be help students clearly state their goals and to keep them in mind while participating in a course. Learning contracts (Knowles, 1975) are useful tools for providing students structure while encouraging independence.

9.2.1.1.3. Metacognitive Awareness

Metacognitive skills appear to have an effect on learners' success with web-based instruction (Hill & Hannafin, 1997). Learners with low metacognitive knowledge — learners that tend to think linearly — may get disoriented when search engines do not return documents that meet the learners' expectations. Learners with high metacognitive knowledge — learners that have the ability to view things from different points of view — may also get disoriented, however, they are able to resolve their problems by revising keywords supplied to search engines or by switching search engines. Sometimes this is called "thinking out of the box" or "thinking horizontally." Instructors must help students switch directions to avoid boxing in their thinking.

Students need tools "to help them monitor their progress and obtain timely feedback on their activities" (Sherry, 1995, pp. 352-353). Monitoring progress entails more than knowing whether "I am getting an A or a B or a C" in the class. Intentional learners monitor their progress as a learner. They are able to reflect on their skills, asking themselves questions such as, "How is my writing here? Is it clear? Will someone else understand what I am saying? Why don't I understand this article? What am I having trouble with? How can I clarify it? What tools can I use?" and so on. To encourage this, faculty need to interact with their students on a metacognitive level. Rather than providing all the information and answers, faculty should model and encourage students to perform self-reflection to foster the development of their metacognitive and lifelong learning skills. For example, faculty may ask their students, "What other words are synonyms with your current search terms? How can you organize your thinking? Have you thought about making a concept map to make the relationships visible? What does that concept map tell you about your thinking? What seems to by hindering you? Who could help you? Is there another direction to take?" and so on.

There are many tools available to help students make visible their thinking. Bonk and Reynolds (1997) suggest the use of graphic organizes including flowcharts, concept maps, diagrams, and decision making trees. Although these are not supported to any great extent in a web environment, they are proven tools that can be integrated into a DL setting.

Learners with good metacognitive skills have greater confidence and self esteem (Hill & Hannafin, 1997). Learner self-efficacy appears to have an affect on learners' success with web-based instruction. Learners that have low self-efficacy — learners that are not confident with their technical knowledge or use of a system — are less likely to try new things or explore new strategies with the system. Learners that have high self-efficacy — learners that are confident with their technical knowledge and skill — are more likely to try new things with the system. Learners that are self-motivated, with high metacognitive skills are less likely to become disoriented when using search engines on the world wide web.

9.2.1.1.4. Time Management

Distributed learning students must be more focused, manage their time more efficiently, and they must be able to work independently as well as in a group (Hardy & Boaz, 1997). Attrition rates in DL programs are extremely high, variously reported from 50% to 80%. Failure to manage time appropriately is a major cause of this attrition. Students are used to attending classes at regular times, which provides a major time management structure. DL programs often leave time for participation up to the student. While faculty need to create an environment that allows students to manage their time and be flexible, they must also not allow so much flexibility that students are able to procrastinate. Students need structure. Some students need more structure than others and instructors should try to identify those students. A learning experience can be miserable if it fails to meet the needs of, or take into consideration the characteristics of, learners, instructors, and support resources (McCormack & Jones, 1997). It also stands to reason that not every teacher is capable of operating as a DL teacher. Teachers must also manage their time well, communicate succinctly, operate at a metacognitive level,

and be comfortable with a sense of "separateness" from their students.

9.2.2. *Dynamic Generative Learning Activities*

REALs involve students in dynamic generative learning activities. Dynamic means that students engage in meaningful and important activities as participants rather than observers. In other words, students are legitimate members of communities of practice (Lave & Wenger, 1991). Dynamic generative learning requires that students "engage in argumentation and reflection as they try to use and then refine their existing knowledge as they attempt to make sense of alternate points of view" (Cognition and Technology Group at Vanderbilt, 1993, p. 16). Studies indicate that knowledge is more likely to be used in new situations when acquired in a problem-solving student-centered mode rather than in a factual-knowledge teacher-directed mode (Adams et al., 1988; Lockhart, Lamon & Gick, 1988). People who learn through active involvement create an "increasingly rich implicit understanding of the world…" (Brown, Collins & Duguid, 1989, p. 33).

Dynamic generative learning, then, involves students deeply and constantly with creating solutions to authentic problems through the development and completion of projects. These kinds of learning activities require a shift in the traditional roles of students and instructors. Teachers become facilitators and guides, rather than presenters of knowledge. Students become active investigators, seekers, and problem solvers working purposefully on a challenge. In generative learning, students *apply* the information they learn to authentic problems. Again, as in intentional learning, teachers must scaffold both the operations of distributed learning and the learning activities of the students.

9.2.2.1. Dynamic Generative Learning Activities and Distributed Learning

9.2.2.1.1. Prepare Meaningful Activities

Meaningful activities are crucial in both REALs and DL environments. Meaningfulness is important for two reasons. First, meaningful activities provide motivation for working in DL. Second, meaningful (and authentic, see next section) activities help learners develop knowledge structures that will enable them to transfer their learning to new situations. Meaningfulness provides context that prevents the formation of inert knowledge (Whitehead, 1929).

9.2.2.1.2. Provide Access to Resources

REALs are resource intensive. Learning activities usually include the need to find new information to support positions, accomplish tasks, and create products. The instructor needs to make sure that students will be able to have access to the data bases and search engines that they will need.

9.2.2.1.3. Create, Create, Create

Dynamic means active and powerful. Dynamic, generative activities require that students create something meaningful and visible. The web provides many ways of creating materials and sharing them, either with the class or the world-wide community of practice. Web pages, presentations, papers, or programs are within the means of students to create. The learning activities need to have students create important products that recognize their peripheral participation in a community of practice (Lave & Wenger, 1991).

9.2.3. Authentic Learning Contexts

In REALs, learning requires the use of authentic cognitive, psychomotor, and affective skills. An authentic task, activity, or goal provides learning experiences as realistic as possible, taking into consideration the age and maturation level of the students and environmental constraints such as safety and resource availability. Authenticity is an important part of a student-centered learning environment for three reasons. First, realistic problems hold more relevance to students' needs and experiences because they can relate what they are learning to problems and goals that they see every day (Blumenfeld et al., 1991; Pintrich, Marx & Boyle, 1993). Second, authentic situations that reflect the true nature of problems enable students to develop deeper and richer knowledge structures (Albanese & Mitchell, 1993) leading to a higher likelihood of transfer to novel situations. Finally, authenticity encourages collaboration and negotiation (Johnson & Johnson, 1979; Lowry & Johnson, 1981). Ill-structured, complex problems require a team approach that provides natural opportunities for learners to test and refine their ideas and to help each other understand the content.

9.2.3.1. Authentic Contexts and Distributed Learning

9.2.3.1.1. Contextualize Learning

Make sure that learning arises from an authentic context. This can be a simulation, case, problem, or task. Contextualized learning is more easily transferred to other situations than decontextualized learning.

9.2.3.1.2. Make Learning Complex

Authentic learning is complex learning. Over simplified learning is neither authentic nor valuable in a contextualized sense. Simplified situations often provide incorrect understandings that get in the way of future learning and refinements (Spiro & Jehng, 1990). Students exposed to a situation in its natural complexity create richer knowledge structures more useful for future application and learning. Additionally, complex learning contexts encourage more meaningful collaboration. Students do not mind collaborating when it is necessary to achieve a goal that one person could not attain on his or her own.

9.2.3.1.3. Use Multimedia to Increase Realism

The WWW through the use and integration of multimedia, video, audio, data bases, hypermedia, networks, and e-mail, allow us to create microworlds that mimic the real world (Collins & Brown, 1986). These microworlds allow for increased complexity and diversity in learning and practice (Collins, Brown & Holum, 1991). They also enable instructors to enhance individualization of their work.

9.2.3.1.4. Encourage Research

Most authentic learning contexts require some kind of research. One of the major strengths of DL environments is their access to people and data bases of information. Research, and especially the search process, should be important components of DL learning activities. Students come into proximity with communities of practice as the Internet serves as a gateway to a world community of learners. Browsers and search engines are vehicles for exploration providing students with critical skills of goal setting, self-directed learning, and testing hypotheses.

9.2.4. *Collaboration*

REALs demand collaboration among students to achieve complex goals. Collaboration acknowledges the social nature of knowledge construction (Bauersfeld, 1995; Cobb, Yackel & Wood, 1992; Roth, 1990). Through collaborative work, students experience and develop an appreciation for multiple perspectives; they refine their knowledge through argumentation, structured controversy, and the sharing and testing of ideas and perspectives; they gain an appreciation for the value of cooperation and the individual strengths that members of the team bring to the group; and, they are more willing to take on the risk required to tackle complex, ill-structured, authentic problems when they have the support of others in the cooperative group. Therefore, with the support of others in the group, students are more likely to achieve goals they may not have been able to meet on their own. Collaboration also facilitates generative learning. Some of the generative activities that students engage in cooperative groups include (Brown et al., 1989):

- Collective problem solving. Groups give rise synergistically to insights and solutions that would not come about individually.
- Displaying multiple view points. Group participation means that the members must understand many different roles. They also may play different roles within the group to gain additional insights.
- Confronting ineffective strategies and misconceptions. Teachers don't have enough time to hear what students are thinking or how they are thinking. Groups draw out, confront, and discuss both misconceptions and ineffective strategies.
- Providing collaborative work skills. Students learn to work together in a give-and-take interaction rather than just dividing the workload.

Conversation, communication, and establishing a community of learners is critical to the teaching and learning process (Pask, 1975). "Successful distance education systems involve interactivity between teacher and students, between students and the learning environment, and among students themselves, as well as active learning in the classroom" (Sherry, 1995, p. 344). Yet, in a DL environment there are several problems to solve when technology is the vehicle for conversation. For example, two people involved in face-to-face conversation exchange gestures, facial expressions, and body language to clarify meaning (Pea, 1994). It is probably impossible to create the same scenarios with technology, however careful management of

the technologies can make student-to-student and faculty-to-student communications more valuable.

9.2.4.1. Collaborative Learning and Distributed Learning

9.2.4.1.1. Student/Student Communication

Student-to-student communication enables students to work in groups, carry on discussions, provide feedback to other students, and engenders motivation to learn (Orgill, 1997). Students can get to know one another through various methods. For example, students can create personal web pages or post autobiographies in a common location. The instructor's role is that of facilitator when students are communicating with one another (Orgill, 1997). The instructor needs to

- Enable group work to be undertaken, form discussion groups, and structure peer assessments to engender motivation to learn.
- Familiarize students with one another. Instructors often forget that it is harder for students to learn who each other is than for the instructor. Take time to give students a chance to learn not just names but the strengths and background that each person brings to the class. Web pages or a simple posting of autobiographies in a public message area are two ways to deal with this.
- Enable private communication between individuals.
- Use white board technologies, list serves, and mailing lists. Send mailing to students immediately following the first class.
- Make sure that technical support is available and that each student can function with basic telecommunication skills.
- Help students learn to label their messages (e.g., idea, supporting argument, opposing argument,

question, point of clarification, etc.) to help students follow discussions.
- Encourage interaction between students through assignments and pairing of interests.

9.2.4.1.2. Instructor/Student Communication

In the REAL paradigm, both the instructor and the student must agree upon course requirements and goals. This agreement is necessary to encourage students to make the course personally meaningful and to take ownership in the course activities. The instructor also needs to concentrate on interacting with the students on a metacognitive level and providing feedback. This means probing the students' thinking, challenging their ideas, and making them think deeply. The instructor needs to

- Identify problem areas and take corrective action, such as assigning remedial work.
- Provide office hours when he/she can be contacted by the students. This is necessary for student expectations and to help the instructor and students manage time. Responding to e-mail and general posting can be extremely time consuming. Setting office hours helps students know when to expect a response and when to check their mail.
- Provide meaningful feedback. Model the behavior expected of students. It is impossible to reply to every message. However, the instructor needs to respond quickly to weak thinking, poor logic, or unsupported statements. Quick action at the beginning of a course will reduce these kinds of problems later. The teacher should ask the types of questions that encourage the students to find evidence, clarify thinking, and analyze ideas (see section on metacognitive awareness in Intentional Learning above). Faculty

can also involve other students in the discussion by asking if they understand another individual's comments. Again, the important point is to encourage thoughtful messages supported by evidence and clear thinking.

9.2.4.1.3. Instructor/Class Communication

Instructor-to-class communication may be synchronous or asynchronous. Synchronous instructor/class communication takes place in a multi-user environment, such as a Multi-user Object Oriented (MOO) session, where more than one person can send a message at a time and all messages are available when they are entered. Commercial conferencing software also enables multi-user communication. In asynchronous environments, such as e-mail, students can read messages in any order because they usually appear in a mail folder. Also, time delays between e-mail messages may be seconds to hours or even days, depending upon student/instructor schedules (Orgill, 1997). Instructor/class communications require the instructor to

- Stimulate significant whole class discussions. Often classes are too large to participate meaningfully in a single discussion. If each person in a 15-member class participates only 3 times, there will be 45 messages to read. That is a lot of reading and writing. Usually a discussion that large deals only with the breadth of the topic. Therefore, hold whole class discussions to a minimum. Rather, the instructor should set up small groups or several topics in which a student selects just one per week. In this way, the students can deal in depth with a single topic and the only person that will have to ready 45 messages is the instructor. It is common to ask students to participate in a single discussion, but to

permit them to monitor the other discussions.
- Spread messages out. In on-campus classes a class may meet once or twice a week. When using electronic discussions, faculty need to ensure that the conversation is spread throughout the week and not bunched up the night before a class meets. Bunched up messages discourage the kind of deep thinking required in a REAL.

Social interaction and collaboration are imperative for students to participate as legitimate members of communities of practice (Lave & Wenger, 1991). Communities of practice not only give students the opportunity to obtain knowledge from the experts but allow them to embrace the beliefs and behaviors of the community.

9.2.5. *Reflection*

Finally, REALs encourage students to reflect on what they have learned and how they have learned. REALs embed self-reflection activities into the instruction to support learning and the development of metacognitive skills. Dewey (1933) described the value of reflection as a component of educated thinking. Students evaluate their learning strategies in terms of what worked and did not work, thinking about what needs enhancing to be more effective next time. They consider how their learning may apply to other problems and situations. To this end, students examine the content, processes, and tools and resources they used during the problem, making personal recommendations for future use (Brooks, 1993; Grabinger & Dulap, 1996).

9.2.5.1. *Reflection and Distributed Learning*

9.2.5.1.1. Reflect on Content

Earlier in the paper we talked about probing, testing, and challenging student thinking. The instructor models this for the students and encourages the students to do

the same for each other. "Why" and "how" questions should be regular features of messages and discussions. Statements should be supported by evidence. Students should be able to explain where information came from and how it bears on the task. In an electronic environment, students can add links to their work to text or illustrations that support their points.

Additionally, students need to reflect on what they are learning. Instructors should ask for regular self-assessments from students and encourage students to keep a journal to maintain a more thorough record of their thinking and learning. Although the instructor can ask general questions, students produce better reflections based on specific questions. For example:

- How did your prior knowledge affect your approach to the project? Be specific in describing your prior knowledge and how it affected your approach.
- What are three of the most important things that you learned about your topic while working on this project? Why do you consider them important? Be specific.
- Do you believe that your learning from this project represents the breadth of the topic? Why?
- Do you believe that what you were able to learn something about this topic in depth? If so, what is that?
- What did you learn that you can apply to other problems or projects? Describe situations where that learning might be applied.
- What topics did you encounter that you would like to study more? How will you do that learning?

9.2.5.1.2. Reflect on Process

The process, or system of learning activities, that the student engages in the DL environment is also part of the learning and, thus, part of the reflection. This is an important part of the metacognitive skills

described in the "Intentional Learning" section above. Again, specific questions about the process and learning activities are important parts of encouraging good reflection. For example:

- What did you learn about your ability to learn? What new learning/metacognitive skills did you acquire? What did you learn that will make you a more efficient and effective learner on future assignments?
- What kinds of learning problems did you encounter while working on the topic? How did you overcome them? Did anyone else offer useful assistance (who and how)?
- How can you improve as a learner? What are your weaknesses? How will you strengthen them? What will you do differently the next time?
- How has the communication environment affected your learning?
- What could make communicating with the instructor or other students more meaningful?

9.2.5.1.3. Reflect on Tools and Resources

Tools and resources are important parts of a DL environment. Students use computers, televisions, radios, the Internet, WWW, data bases, and productivity packages. We do not yet know if the learning that takes place in a DL environment is the same as the learning that takes place in a classroom, therefore it is important for students to reflect on the effects of the tools on their learning. For example:

- Did you believe that your learning using the DL environment is equal to what you would have learned in a traditional classroom environment?
- What resources did you identify that you will use again? Why?
- What search engines were useful? Why?

univers-itr. weiz. 98
new technologies for higher
education

- What data bases were most useful in your research? Why?
- When you had trouble finding the information that you needed, what did you do?

Each REAL attribute builds upon and uses the others.

9.2.6. *Summary of REAL Attributes*

None of the attributes are mutually exclusive, and no one attribute is more important than another; you cannot implement one feature without incorporating the others to some degree. Hannifin (1992, p. 51) describes learning environments as "comprehensive, integrated systems that promote engagement through student-centered activities, including guided presentations, manipulations, and explorations among interrelated learning themes." In effect, the attributes of REALs mirror the comprehensive, integrated, and holistic nature of constructivist theories. The characteristics are symbiotic, with one feature both supporting and needing the others to create a successful rich environment for active learning.

The importance of REALs as comprehensive and integrated cannot be over emphasized. A persistent problem in implementing REALs is the intellectual acceptance of the underlying constructivist philosophy but a rejection of what that means in application. The changes that most teachers must make to use REALs are significant. It is not easy to give up years of control and didactic teaching methodologies — particularly when parents and administrators must also be convinced of the value of utilizing REALs. Teachers also feel the pressure of preparing their students for standardized tests and must "pour" in as much information as possible. So, while teachers often are able to use more authentic problems in their classes, they often maintain tight control over the direction of the problem or task and fail to give students meaningful responsibility. This results in turning what could be dynamic generative learning into just another assignment.

This same problem shows up in distributed learning applications. It is an interesting conundrum that many designers of distributed learning applications create programs that wind up constraining the students to following specific paths or methodologies rather than enabling them to become more intentional learners.

9.3. RESEARCH ISSUES

There is one thing missing in this equation — research — and we are as guilty as others in our paper. There is a lot of talk without a solid research base. Are the recommendations we make empirically verified? For the most part, no. They are, instead, recommendations that make good sense for teaching in any environment. The implementation challenge is to find ways to make those recommendations happen in DL environments. The research challenge is to discover the effectiveness of those recommendations specifically and DL generally (Windschitl, 1998).

Jones and Paolucci (1998) conducted a thorough review of the literature of the kinds of research being done on instructional technology issues (not solely distributed learning issues). They found less than 20% of the research reviewed directed at identifying learning outcomes derived from technology. Instead, 50% of the research looked at developing methodologies, applications and installing instructional technologies. They found that 20% of the research in the area is subjective (qualitative) 12% is empirical and objective in nature. They state

In summary we conclude that only 12% of total research being published is associated with

quantitative documentation of learning outcomes and achievement, which we deem the *effectiveness* of the technologies being adopted. Our observations suggest that approximately 5% of total research is conducted using formal methods such as control groups with *comparative* learning outcomes (i.e., experimental). (Jones & Paolucci, 1998, p.12)

This is a critical issue in discussing potential research in the area of distributed learning and REALs. We seem to be having a problem finding ways to measure the effectiveness of technologies in instruction. Hawkins (1993) and Rockman (1993) state that one of the reasons for this is that technology effectiveness is not easily captured using current standardized tests. Admittedly this is a significant problem, especially in a REAL environment. REALs require more authentic kinds of assessments such as portfolios, actual practice, presentations, or creations. However, if we are to convince those who handle the purse strings that technology and REALs are valuable, we are also going to have to provide comparative test data. Again, Jones and Paolucci (1998) state

> Regardless of the reasons why, as we approach a second decade of educational micro-computer technology applications and infusion, it is important to pause and assess the research focus (or lack of) presently given to educational technology effectiveness by academic community. (p. 11)

Now there is little, if any, data that suggest that large infusions of technology in education are cost effective. In fact, two major European studies have found the opposite, that technology poses significant problems in education (Gardner, Morrison, Jarman, Reilly & McNally, 1992; Watson, 1993). Additionally, we cannot rely on

studies that focus on adoption of technologies and various surveys of satisfaction by students and teachers to provide a strong argument for using technology in education. Instead, we must ask "Is there a difference in quality (i.e., learning outcomes) between traditional delivery and those alternatives involving technology? Furthermore, is any proven difference acceptable" (Jones & Paolucci, 1998, p. 13)? Even more pointedly, Jones and Paolucci ask, "Is a degree earned through a program using asynchronous learning delivered over the World Wide Web equivalent to a degree earned through an on-campus residential program" (p. 13)?

Jones and Paolucci's questions are large. We can break them down a bit with small questions that can help answer their larger issues:

- How can we measure learning in DL environments that invites comparisons with other environments?
- What effect does teacher and/or student technical aptitude have on teaching and learning?
- What effect does individual learning styles have on DL environments?
- Are there fundamental pedagogical changes between DL and classroom environments (Windschitl, 1998)?
- How do people in both environments perform on realistic problems or tasks?
- How does the role of the instructor change in a DL environment?
- What attributes predict the success of a learner in a DL environment?
- What kinds of artifacts lend themselves to meaningful analysis?
- Does labeling message increase the quality of participation in on-line discussions?
- What is the effectiveness of asking students to set specific goals on

learning and the attrition rates of DL programs?

- What effect does self-efficacy have on the completion rates of students in DL programs?
- Can concept maps provide effective ways of comparing knowledge structures?

These are just a few of the questions that we can begin asking. The important issue is that we learn the effects of technology on learning, teaching, thinking, and working.

9.4. CONCLUSIONS

We come to the end of this paper. Is there anything new in here? Fundamentally, no. We contend that good teaching is good teaching whether it is over the web, radio, TV, or in a classroom. However, the technology always makes things different. Sometimes it presents obstacles, sometimes it removes obstacles. The important thing is not to get bound up in the technology at the expense of pedagogy. Rather, technology must serve the pedagogy.

We believe that what our research review points up most clearly is that there is a significant gap between technology and pedagogy. We have a tendency to talk about the wonders of technology without ever knowing if it really works. When people do research, they are more likely to look at their system and its implementation rather than the learning effects.

We can take this further and examine DL programs that claim to incorporate REALs or constructivism. Frequently, there is an inherent contradiction in these systems because they focus on what the system does FOR the learner. Thinking they are creating a tool for learners but what they are really creating is a constrained anti-constructivist system that forces the learner along specific paths or through decontextualized activities. Often these systems take away the ability for an

individual to construct knowledge in an individual way. People talk about constructivism and then want to break things down into simpler components. This is the antithesis of authenticity and dynamic generative learning activities. For example, many applications break up "learning" versus "learning to learn" whereas in reality the two are inexorably intertwined. There are often very good applications that look at the specific attributes of constructivism but ignore the construction of an overriding context and realistic application, decontextualizing the learning experience.

It is fine, in our minds for technology to push pedagogy along. However, there is a fine line between enabling pedagogy and creating pedagogy. Research and theory provide the foundation for good instructional practice. Technology, by definition is the application of theory to accomplish something practical. We hope that researchers and technology creators keep this in mind and make technology must serve the pedagogy, not create the pedagogy.

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new technologies for higher
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10. USE OF COMPUTERS IN PHYSICS EDUCATION
INVITED PAPER

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Abstract **- Physics is said to be a difficult subject. Among the reasons for the learner's difficulties, one has been subject to intense research: the naive conceptual framework in which students insist to explain the world around them. Nevertheless, there have been more questions arising than answers provided to solve these kinds of problems. We point out the role of computational techniques, namely Simulations, Multimedia, Telematics, Virtual Reality, and computer Based Labs which may deal with those difficulties and increase the learning success. We describe our ongoing experience in the field.**

10.1. PROBLEMS WITH PHYSICS LEARNING AND COMPUTER APPROACHES

Science learning, in particular Physics learning, is not an easy task. Two examples suffice to give an illustration of that. Portuguese final exams at the end of secondary studies show the lowest grade point averages in Physics and Mathematics. On the other hand, in various Portuguese universities, General Physics is considered by freshmen to be a very difficult course and statistics accumulated along the years show persistent negative results.

There is strong evidence all over the world that introductory Physics students in the usual university lecture courses are not learning the concepts necessary to a good understanding of the physical world. Moreover, students leave their courses with some fundamental misunderstandings of the physical world essentially intact: their learning of scientific facts remains in the classroom and has no later effect on their thinking [19-21]. Student performance does not seem to depend on whether students have or not taken physics courses in high school [20] and the ineffectiveness of university courses is independent of the apparent skills of the teacher.

Anyone interested in this problem should deal with two types of questions:

- ❑ how students learn Physics and Mathematics;
- ❑ how to use computers to improve learning.

These aspects are of course intimately related, *i.e.*, the best use of modern interactive media should be based on our best knowledge on the way students learn.

Alfred Bork and Seymourt Papert, a physicist and a mathematician, were pioneers in this type of approach.

Bork, in June 1978, in an address to the American Association of Physics Teachers, under the title "Interactive Learning", enounced a prophecy which has been fulfilled only partially [1]:

"*We are at the onset of a major revolution in education, a revolution unparalleled since the invention of the printing press. The computer will be the instrument of this revolution. Although we are at the very beginning - the computer as a learning device in current classes is, compared with all other learning modes, almost nonexistent - the pace will pick up rapidly over the next 15 years. By the year 2000, the major way of learning at all levels and in almost all subject areas will be through the interactive use of computers.*"

According to Bork, some advantages of using computers in education are the following [2,3]:

❑ Interactivity. The computer allows every student to play an active role in the learning process, in contrast to the passive role of lecture and textbook formats. The student is no longer a spectator, but is an active participant in the learning process. There is a multiplicity of situations to be explored and this can be done at the user's discretion.

❑ Individual attention. Educators know that students are different. Not all students have the same backgrounds and not all students learn in the same way. However, many of our conventional approaches to education use a rigid procedure for all students and do not allow taking these differences into account. An advantage of the computer is that, with good software, it can individualize instruction. Furthermore, as all students do not learn at the same rate, different students need different times to go through the learning material. The computer also allows that.

These ideas helped to abandon an initial stage of computer use in education, in which computers were basically tutorial machines running software which was designed to "program" students according to some fixed scheme. Bigger interactivity and feedback were needed to respond to the modern pedagogical theories.

Another important factor in the advance of computer use in education was that computers quickly became more powerful, therefore more and more suitable to implement new ways of learning. They got more rapid central processing units, taking advantage of the enormous miniaturization, more memory, both central and backup, and all this was provided at less cost. Graphic capabilities have improved considerably, allowing for full animation, realistic three-dimensional images, etc. A landmark which helped to democratize computers was the appearance of the personal computer in the late seventies.

Some interactive computer environments may indeed help the student to correct his non-scientific preconceptions. These are usually naive but extremely persistent. A way of correcting a wrong mental model consists in allowing him/her to explore the model using a simulation and to contrast the results to the correct scientific model and to reality. These computer environments are usually richer if they have some characteristics of a play [25]. Computer games provide challenges, require mental skills and offer a quick feedback. In computer games the difficulty level is incremental, attracting always the player's interest, but never so much that he loses interest for being unable to reach the goals. In the best simulations there is a fragrance of the game: good programs invite the user to explore, to try new commands and menus, to go forward, in a word to win the "play". Alfred Bork in the above mentioned speech said: "*Play is a way of gathering, under highly motivated circumstances, a variety of*

experiences, possibly even focused experiences. An experiential base is a vital ingredient in the learning process".

Some good computer programs for learning physics exist which are essentially computer games:

❑ *Electric Field Hockey*: a program written by Ruth Chabay, and published in the "Physics Academic
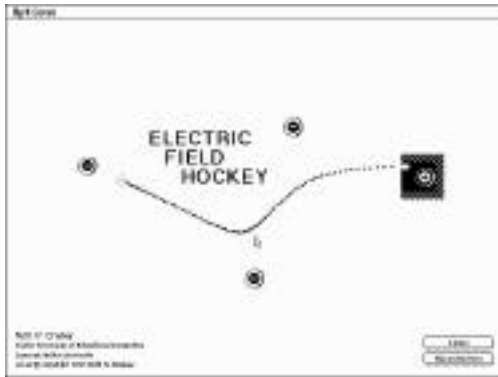
Figure 1 – The *Electric Field Hockey* software.

Software" collection of the American Physical Society, teaches electric forces, putting a ball with a charge and driving it through conveniently applied forces (due to other electric charges) to a goal

Figure 2 – One example of *Graphs and Tracks - Part I*: *From Graphs to Motion*.

(Figure 1).

❑ *Graphs and Tracks*: a program of David Trowbridge, and also published by the American Physical Society, which is not only an educational game but also a good example of the contributions that educational research can make to the development of computer-based instruction [9]. The creation of *Graphs and Tracks* was motivated by the investigation of student's difficulties with motion graphs. Since it deals with misconceptions on Mechanics, a basic subject of Physics, it is worthwhile to examine it in more detail.

The program is designed to help students to improve their ability to relate an actual motion to its various graphical representations. The physical system consists of a ball and tracks. The program includes a couple of example problems. For each problem, the computer presents a position versus time graph, a ball on a set of tracks, and two initial conditions (Figure 2). The student's task is to modify the track arrangement and initial conditions so that the ball will reproduce the motion represented in the graph. On the other option, the student should draw a graph corresponding to the motion along a given track (Figure 3).The original program made no judgment about whether the graph generated by the student was acceptable, nor did it provide any feedback to help the student decide which sections of the graph were improperly arranged. The student was responsible for detecting any errors, determining what changes were needed and deciding when the match was good enough to proceed to another example.On the current version there is a help screen that the student can request. If the graph generated by a proposed track arrangement fails to match the given graph, the help option
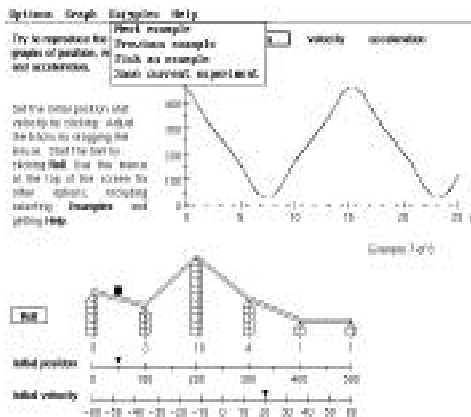
can guide the student in searching for errors. Student's attention is directed, as appropriate, to the choices of initial position and velocity, or the slope of a particular section of the track. The
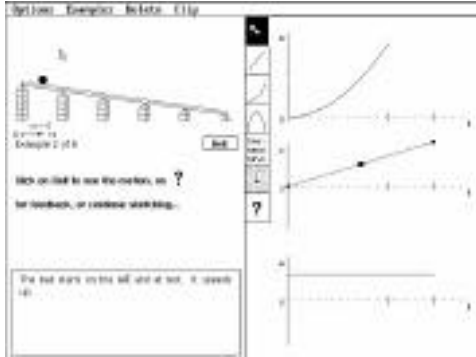
Figure 3 – One example of the Graphs and Tracks - Part II: From Motion to Graphs.

program assumes, therefore, some guiding role. The use of this kind of software is very instructive to deal with conceptual difficulties. The strategies that the students invoke may be observed with minimum influence by the investigator on the student's approach. Errors may be classified in typical categories.

Emergent computational tools and new developments in learning theories have contributed to changes in education. However, the results are still far from the best initial expectations. Different reasons may explain this phenomenon (*e.g.*, the reaction to change by school, which is a rather conservative institution). But it seems that we are still in the middle of the change process. Further progress should be made taking into account the rich accumulated experience. Let us sketch what have been the main ways of using computers in Physics, present our own experience in using these different ways, and, finally, write down conclusions and some prospectives.

10.2. DIFFERENT WAYS OF USING COMPUTERS

Today we may distinguish different ways of using computers for teaching and learning Physics [4,24]:

10.2.1. *Simulations*

This has been probably the most explored field. The above mentioned examples of computer games are basically simulations. So are many programs which have won the

Figure 4 – Running the *Interactive Physics* software.

software contest organized by the journal "Computers in Physics" (a couple of them published by the "Physics Academic Software" initiative of the American Physical Society), the series *CUPS*, published in book format by John Wiley [7], the program *Interactive Physics* (Figure 4), a powerful simulation tool published by Knowledge Revolution, etc.

We talk about simulations when we run in the computer a model of Nature. Sometimes the word modelization is used when the emphasis is on building, *i.e.*, programming the model, while simulation is left for the situation when the model is considered a "black-box". This distinction is somewhat artificial and not always clear. Since the laws of Physics are expressed by differential equations, it is normally easy to implement a

simulation for a given physical problem: this may be for instance the free fall of a stone, the orbital motion of a planet under the influence of one or more stars, and even the collision of two galaxies. However, simulations may also be made when we do not have a differential equation but an iterative relation: that is the case of the logistic map, a difference equation used in introductory studies of chaos.

Simulations should never entirely replace reality but are extremely useful when we have to study experiments which are impossible to do in practice (for being very expensive, very dangerous, very slow, very fast, etc.) Normally simulations offer the possibility for pedagogic exploration and sometimes, when the ludic element is present, give a reward for accomplishment some goal.

10.2.2. *Multimedia*

This modality is based on the concept of hypertext or, more in general, hypermedia. The word multimedia means that modules include a variety of elements, such as texts, images animations, simulations, and video clips [28]. The motto is "an image is one thousand words worth" so that the information should be as visual as possible. An hypertext module has several internal links and a reader does not need to follow a linear or sequential path through the module but, based on his experience and interests, may easily select those parts of the module that are of interest to him at the moment. Other links will enable users to move efficiently between different modules. Essential features of multimedia are interactivity and flexibility, *i.e.*, the possibility of entering commands and the ability to choose a path within the provided information. Since, according to some pedagogical theories, these factors are required for good learning, the educational advantages of multimedia have been widely advocated. The defenders of multimedia say that it is the convenient format for learning due to the fact that our brain processes

information by free association of concepts in a intrinsically non-linear way. However, the sequential way, which still presides to the organisation of most courses, seems to be more adequate for systematising contents.

Multimedia may be on-line or off-line depending on the way that information is offered. A connection between these two supports is nowadays easily made. Multimedia off-line did not undergo the big explosion it has been announced, perhaps due to the enormous progress of the on-line format, which is mostly free. Anyway, these are several useful educative works: a nice example of the use of multimedia in Physics is the CD-ROM *Cartoon Guide to Physics* (Figure 5), based on the book with the same title by Larry Gonick and Art Huffman [8]. This disk may be used in Physics classes, although it is more recommended for extra-class activities. Like other multimedia products created for science learning, it includes several interactive simulations. Although the success of multimedia in science education has been restricted so far, its role in motivating students should not be disregarded. Even before the conceptual difficulties of the students emerge, lack of

Figure 5 – Image of the *Cartoon Guide to Physics* CD-ROM.

motivation for studying science may be the main cause for failure.

10.2.3. *Telematics*

The Internet, the network of all networks, has known a big success in the society in general and in schools in particular [25]. Its use for science teaching and learning shows still a big potential in spite of the amount of interesting work already done. Computer use in a network includes playing with simulations (these may be downloaded from the net or simply explored on-line if they have been written in the Java language), multimedia (HTML, the standard of the World Wide Web, is a multimedia language), and Virtual Reality (VRML is the standard for representing 3D objects or scenes on the Internet). Let us look at the way in which Internet is changing our teaching and learning styles.

In the prevailing education model, the teacher plays the main role, determining the pace of learning. Taking advantage of new technologies, more interactive and more personal learning may be implemented. The teacher should then help the student in a different way, for example in searching and selecting information relevant to a given goal in the middle of the enormous and disordered information oceans. Under these circumstances, his role will be no more central (one speaker at the stage and many listeners) to become peripheral (many speakers and many listeners). The teacher will no more be the information's single owner and provider to become an expert and consultant for discussing matters and solving problems. The World Wide Web became the biggest and the most lively of all libraries and the classroom walls have been demolished with the direct link to that source.

At the same time, the Internet represents a big step towards a bigger democratization of education, with equal opportunities being given to every student, independently of its geographical situation (if we are able to handle the known info-exclusion problem). Many courses exist on the Web and may be accessed by everybody from everywhere. A good example of Internet use for teaching

Physics is the Java-based General Physics course at the Davidsson College, North Caroline, USA.

Sometimes, it is not only the aspect of the course but also the contents, which are new. Let us consider an example of revolution in learning contents which is being presented on the Web. One of the features of present education is the compartmentalization and specialization of instruction by departments and even by subgroups within departments. While this is understandable, and even necessary to some extent, it has the effect of obscuring the connections between different fields. For example, students in Mathematics classes often do not know how Mathematics is applied in engineering or science. At the same time, students in engineering or science courses repeatedly fail to recognize that the ideas and methods they learned in calculus or linear-algebra classes are what they need to solve problems they are bind.

Some universities have begun to explore other ways of organizing the education of scientists and engineers. For instance, the Rensselaer Polytechnic Institute, New York, USA, offers courses in what they call a "studio mode" [10]. For example, the "Mechanics, Linear Algebra, and the Bicycle" module is not designed to teach
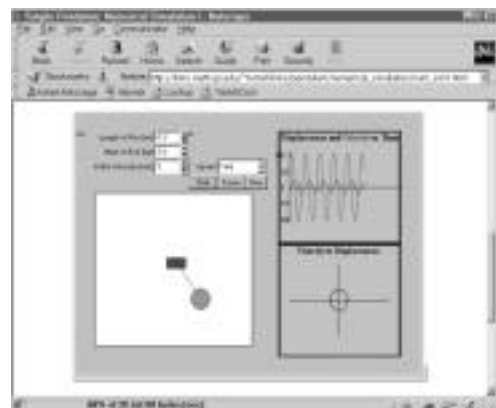
Figure 6 – A *Java* applet for studying the pendulum from the "Differential Equations and Mechanical Oscillators".
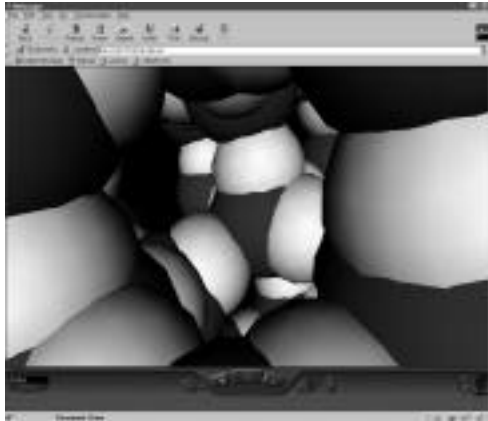
Figure 7 – Navigating through ice with the help of VRML
from the "Virtual Water" project.

everything about mechanics, linear algebra, or bicycles. Instead, the module is meant to be a guided tour through some concepts of mechanics and related mathematical techniques, namely vectors, matrices, and sets of linear equations.

The module intends to draw on a student's interest in understanding how and why a bicycle is made the way it is. The module offers opportunities for a student to learn about mechanical and mathematical details, being its main theme is the link between mathematics and engineering in physical models. As a graphical demonstration, there is a Java applet that allows a student to create new bike shapes in two dimensions.

On the other hand, the "Differential Equations and Mechanical Oscillators" module is directed towards the study of mechanical oscillators. The first approach is analytical and conceptual. Assumptions based on engineering are used to reduce the actual physical system to a simple model. Then, application of the laws of Physics leads to a mathematical model, which consists of a system of one or more differential equations taken together with initial conditions. The oscillator module is divided into three parts. The first is devoted to an in-depth treatment of a mass attached to a vertically hung elastic spring; the second

concentrates on the motion of a simple pendulum (Figure 6); and the third treats a spring-pendulum system in which the rod of the simple pendulum is replaced by an elastic spring.

VRML offers another possibility of using the Internet. It extends the usual HTML interface with the ability to visualize three-dimensional scenarios and interact with their basic elements. In areas like molecular science and solid-state physics, where the models need 3D representations, the new technique can be applied very effectively to improve understanding (Figure 7).

10.2.4. *Virtual Reality*

With Virtual Reality the focus of learning is placed in the conception of environments that allow students to interact with the computer with minimal restrictions [29]. According to Papert [26], a good learning environment requires free contact between the user and the computer. The reduction of the interface is precisely a necessary condition to immersive Virtual Reality. Two important implications result from immersion. First, there is a smaller distinction between the user (student) and the computer information (object of knowledge) [23]; second, immersion allows for a non-symbolic interaction with the environment.

The main characteristics offered by Virtual Reality to education are immersion (most sensations come from the virtual environment), interactivity (free navigation, choice of referential, etc.) and manipulation (actions performed as in the real world). Virtual Reality brings together a set of characteristics that make it a unique technology as a learning means:

- Virtual Reality is a powerful visualization tool to handle 3D problematic situations.
- Virtual environments allow learning situations by trial and error that might encourage students to explore a wide choice of possible solutions.
- The student is free to interact directly with the virtual objects, allowing first-

hand formulation and verification of hypothesis.

- The virtual environment can offer adequate feedback, allowing students to focus their attention on specific conceptual errors.
- Virtual Reality can collect and show complex data in real time.
- The immersive nature of Virtual Reality can endow students with extra capacities to retain information.

The "ScienceSpace" project [5, 27] is a good example of the application of the Virtual Reality in education. It consists of a series of virtual worlds designed to aid students in mastering challenging concepts in science. The project is a join research venture between George Mason University, the University of Houston, and NASA's Johnson Space Center, USA. "ScienceSpace" consists of three virtual environments (Figure 8 a-c):

- *NewtonWorld* provides an environment for investigating the kinematics and dynamics of one-dimensional motion.
- *MaxwellWorld* supports the exploration of electrostatics, leading up to the concept of Gauss' law.
- *PaulingWorld* enables the study of molecular structures via a variety of representations.

Another project, "Water on the Tap", is carried out at the University of Washington, Seattle, USA (Figure 8d).

10.2.5. *Computer-Based Laboratories*

Physics is an experimental science and the computer found already a place in the Physics laboratory. The richness of Computer-Based Labs and associated modeling tools could have a major impact on physics teaching and learning (Figure 9). We can use these tools to make Physics far less formidable for students with low mathematical abilities. We can use them to place more emphasis on intuition, and, at the same time, to give students the ability to

a)

b)

c)

d)
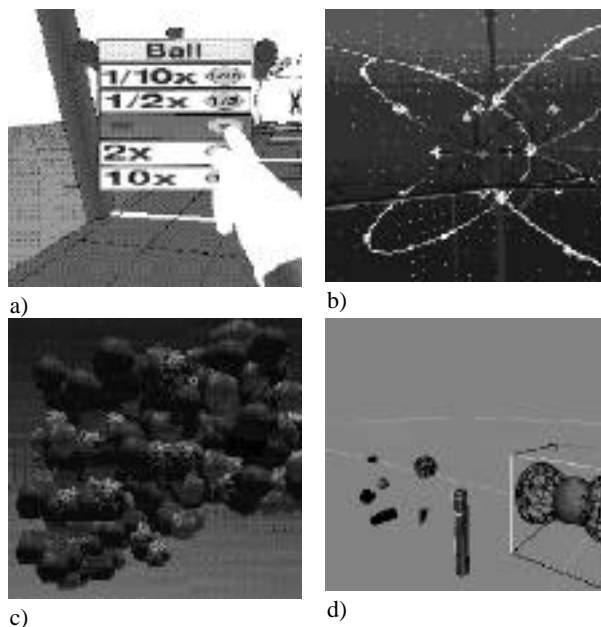
Figure 8: Virtual environments for teaching physics: a) *NewtonWorld* from the "ScienceSpace" project; b) *MaxwellWorld* from same project; c) *PaulingWorld* from the same project; d) a virtual environment for the study of atomic and molecular structures, showing the $2p_1$ orbital from the project "Water in the Tap".

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new technologies for higher
education

solve complex problems.

Perhaps the most important possibility created by this technology is that it allows students to undertake their own original investigations. Much of what is wrong with science education is that students usually only learn about science: they do not participate in a meaningful way. Students at every level should have an opportunity to do real Physics experiments, to participate fully in learning new facts about the natural world. Hands-on participation provides not only a strong motivation but, more important, is the only way to give students an accurate
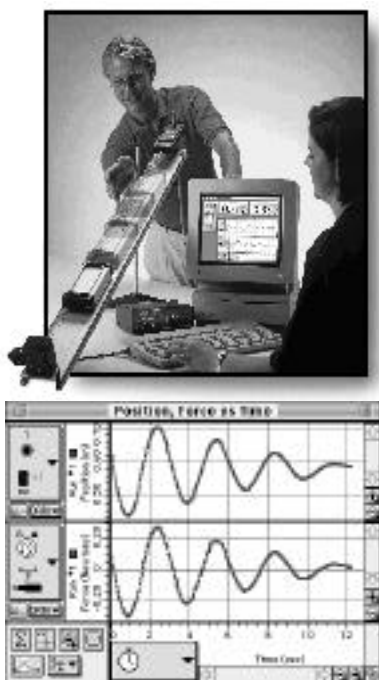
Figure 9 – The Pasco hard and software for a Computer Based Lab.

understanding of science, whether their careers will lead them into science or not.

Learner-controlled explorations in the Physics laboratory with real-time measurements give students immediate feedback by presenting data graphically in a manner they can understand. Using sensors and software, students can simultaneously measure and graph physical quantities such as position, velocity, acceleration, force, temperature, etc. Those tools provide a mechanism for including in Physics teaching methods, which are found effective by educational research to deal with conceptual difficulties. The ease of data collection and presentation encourage students to become active participants in a process, which leads them to ask and answer their own questions. The real-time graphical display of actual physical measurements directly couples symbolic representation with the corresponding physical phenomena. Moreover, the comparison of real data with simulations is a very rich pedagogical tool.

10.3. OUR EXPERIENCE

10.3.1. *Simulations*

The Portuguese Physical Societies for Physics, Chemistry and Mathematics undertook in 1991 a common action - "Softsciences" - for producing and publishing educational software, mainly for the high-school but also for first year university courses.

In the following, we present a short description of some of our programs (see [11] for more information):

- *Kepler* (Figure 10), simulations of planetary systems with one star and one planet, two stars and one planet and one star and two planets.
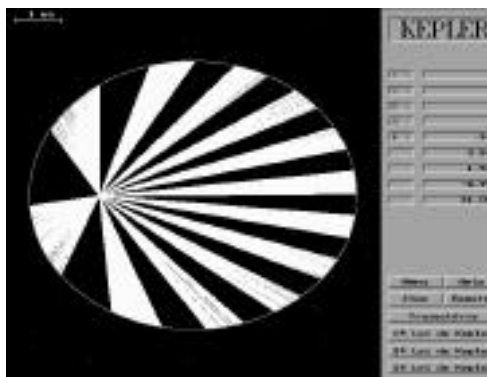
Figure 10 – The program Kepler from the "Softsciences" project.

- *Millikan*, a simulation of the famous experiment done by Robert Millikan to measure the electronic charge. The English beta demonstration program may be downloaded [13].
- *Relative*, a program on object motion in different, inertial or accelerated reference frames.
- *Periodic Table* (Figure 11), a very complete database containing information about the chemical elements. A reduced version of the periodic table in English is available on-line [17].
- *Energy*, a strategy game which allows for the management of Earth's energy resources during the next 150 years.
- *Le Chat*, graphic illustrations of chemical equilibrium. The English demonstration version of the latter may be downloaded [12].
- *Throw!*, a simulation of javelin motion under the forces of gravity and air resistance.

All these programs have been included in a CD-ROM, named "Omniscience", published in 1997 and 1998 with the support of the Ministry for Science and Technology (Figure 12).

10.3.2. *Multimedia*

We have produced and included in our CD-ROM a multimedia edition of the *Periodic Table*, with large number of images, animations, videos, etc.

We have planned for a multimedia project based on the book "The Fun of Physics" [6].

10.3.3. *Telematics*

Recently, the Portuguese Ministry for Science and Technology has implemented an action for placing an Internet connected computer at the library of every Portuguese middle and high school.

We are providing educational contents that are available on line to schools and homes. A lot of information on "Softsciences" is on the Web. The oldest programs may be free downloaded. We have developed, as a

framework for our materials, the "Omniscience" homepage, which is connected to the above-mentioned CD-ROM [18]. It encompasses all our software titles and educational materials.

One of our Web projects is called "READ Sciences" [14]: it includes science resources (*e. g.*, science experiments, a database with books on popular science, lists of the best science videos, etc.). Another of our pages is "Nonius" [15], honoring Pedro Nunes, a 16th century Portuguese mathematician: this, centered on Mathematics, offers not only a lot of links to the math educational world but also many items of our own. Our most recent feature is an educational resource Web page for Chemistry. That
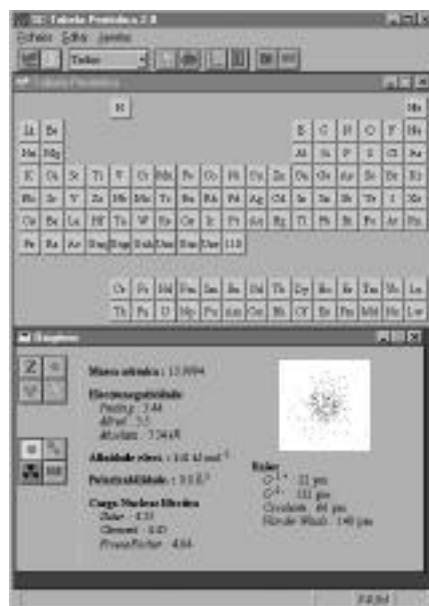
Figure 11 – An image of *Periodic Table* from the "Softsciences" project.

page contains an English section on chemical equilibrium [16].

10.3.4. *Virtual Reality*

Visualization of the electron orbital concept continues to challenge and intrigue chemical educators [22]. The orbital

Figure 12 – The front page of the "Omniscience 98" CD-ROM.

concept is crucial to the serious chemistry student who is exploring the nuances of atomic and molecular structures.

On the other hand, with the increased power of computing resources, it is more and more common to model systems atom by atom, moving each atom or molecule in response to the forces acting on it. From simulations like this one can better interiorize microscopic models and better understand a given substance's behaviour.

In collaboration with Centro de Computação Gráfica, Coimbra, Exploratório Infante D. Henrique, Coimbra, the Physics Department of Instituto Superior Técnico, Lisbon, and the High Education School for Technology and Management, Guarda, we are also developing the "Virtual Water" project, a virtual reality work applied to the learning of the Physics and Chemistry of water (Figure 13). The topics covered in the project go from the molecule geometry to the structures of the solid, liquid and gaseous phases, through the electronic density and the chemical bonding by hydrogen bridges. Atomic orbits are also included.

The project is being done in two phases: the first includes the visualization of the water molecule geometry, the hydrogen bonds, the molecular orbitals of water, the molecular electronic density and hydrogen

wave functions. The second will include classical molecular dynamics of the solid, liquid and gaseous phases, phase transitions, and vibrational normal modes.

10.3.5. *Computer-Based Laboratories*

The Portuguese Physical Society, with support received from the Ministry of Science and Technology, is developing a project for introducing sensors and computers in Portuguese high-school laboratories. Up to now, 20 schools throughout the country has been equipped. Two workshops oriented by experts and regular support in loco provided by university students assured the necessary help for working with the new technologies.

10.4. CONCLUSIONS

After briefly referring to the conceptual difficulties in learning Physics, we have focused on the role of computer technologies to deal with them. We have classified the different uses of computers in Physics, besides the more trivial ones (like word processing, spreadsheet, etc.). Our division was schematic, since each type of use cannot be completely separated from the others. Simulations and Multimedia have already been much explored, in some cases achieving visible success for learning (namely some simulations with a game look) but also knowing some insuccess (Multimedia did not correspond to the hype). Telematics, Virtual Reality and Computers-Based Laboratories seem to be the more promising fields. They need to be further and better explored.

A word of caution is in order. We are not able to anticipate the future in this fast evolving domain. Probably new uses will be added to our list. For instance, nowadays the immense computer power of the Internet is being underused. Cooperative work with
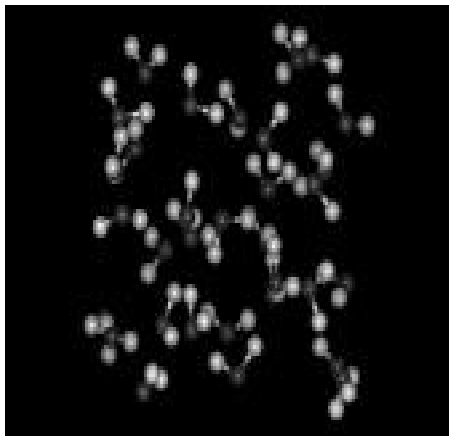
Figure 13 – A frame showing liquid water, from the "Virtual Water" project.

students participation taking advantage of that computer power to solve real scientific problems is a possibility that is starting to be explored. Science Education can only gain from being close to science.

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uniwers.ıfr. v.ınz. 98
new technologies for higher
education

11. THE ROLE OF EVALUATION IN ENSURING EXCELLENCE IN COMMUNICATIONS AND INFORMATION TECHNOLOGY INITIATIVES
INVITED PAPER

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The University of Huddersfield - UK

Abstract-This lecture will present a rationale for evaluation as an essential, integral component of all ICT development programmes. It will begin with a critical review of some of the different approaches to evaluation that have been developed over the last twenty-five years in Europe and the United States. It will pay particular attention to ways of involving users in the design and conduct of the evaluation. The central section of the paper will look at the range of purposes for which evaluations are commonly commissioned and the ways in which evaluators can respond to these. Different methods are appropriate for different anticipated outcomes. In particular there is nearly always a need to ground conclusions in the analysis of both quantitative and qualitative data. The paper will end by arguing that there is a continuum between the formative and summative functions of evalution; and that the evalutor has an important additional role in raising the awareness of sponsors and programme directors to key leanings from evaluations of previous research and development work. Drawing upon a small number of previous evaluation studies it will identify characterstic problematic features of development work in the field of new technologies in Higher Education and suggest ways in which these can be minimised in future programmes.

11.1. INTRODUCTION

This conference is taking place at a time when it is possible to envisage that CIT could begin to deliver some of the educational goals which have been promised for the last two decades. The technology itself is now much more user-friendly; the community of software engineers and developers has the benefit of experience; the internet has given us an accepted international platform for delivering and accessing material; and, despite disappointments, EU and national policy-makers and politicians are still providing substantial funding (compared with the funding available for other initiatives).

However, we should not be lulled into underestimating the difficulty of the task. In this paper, I will argue that evaluation is an essential, integral component of all innovative programmes, and is particularly important in the field of CIT because of its complexity and the technical demands it makes on users. The UK government invested a very large amount of money in innovative programmes to develop the use of CIT in education during the 1980s, with almost no investment in their evaluation (MacDonald, 1992). I think it is now generally recognised that this was a mistake. Certainly, those programmes had some successes, but opportunities were lost for policy-makers to learn from what went wrong. Those of us working in the UK were able to observe repeated patterns of problem and failure that were all too predictable from evaluation studies of similar technology innovations in the USA in the 1960s and 70s (House, 1974). Meanwhile, common sense judgements were made by officials about the incompetence of programme directors and other key personnel, evidence was suppressed and mistakes in programme design were ignored and repeated (e.g.

Richard Fothergill's final report of the Micro-electronics Education Programme was never published so that officials were not subject to public scrutiny when designing the follow-up programme, the short-lived Micro-Electronics Support Unit) (Fothergill, 1987, unpublished). The fact is that UK policy-makers lost faith in evaluation studies because they conceived of their purpose too narrowly; put another way, evalutors lost the trust of policy-makers because they operated on different assumptions from the sponsors about the purposes of studies. Stake (1998) provides a case study which goes some way to explaining the differences in values and motivations which lead to this kind of grave misunderstanding and the ethical implications for evaluators. Fortunately, the situation has now changed in the UK and evaluators have been able to make an important contribution to CIT developments in the 1990s, albeit their reports have sometimes been contentious (Scrimshaw 1998; Underwood, 1994; Coopers and Lybrand et al. 1996).

In this paper I will begin by outlining the many purposes for which evaluations are commonly commissioned. I will then go on to discuss the characteristic problematic features of development work in CIT. And I will finish by putting forward a model for evaluation that can help to ensure excellence in CIT programmes.

11.2. THE PURPOSES FOR WHICH EVALUATIONS ARE COMMISSIONED

Although it may appear that the purpose of evaluations is obvious, they are in fact commissioned for many different reasons. They are always concerned with judging the value of what has been achieved, but the basis for judgements, the uses to which these judgements are put, and the range of stakeholders who have a right to know the outcomes of the evaluation may vary

considerably. An important part of the evaluator's role is to discover the sponsor's purposes, both explicit and hidden, and take these into account when designing and carrying out the evaluation.

Ideally, an evaluation could be said to be primarily educative. Its purpose is to find out what has gone well and what not so well, in order to learn from this. This educative purpose may focus mainly on the future, by drawing out lessons at the end of the programme and making them available to inform the design and conduct of future programmes. Or it may focus more upon the current programme, drawing out lessons during the course of the work and feeding these back to those concerned so that the work of the programme can be continuously improved while it is on-going. The former are sometimes called 'summative evaluations' and the latter 'formative evaluations'. In practice, most evaluations have both summative and formative elements, which are inter-related, but they usually have a stronger orientation to one than the other. The notion of an educative evaluation fits well with the concept of a 'learning society' but sponsors often find it an unexpected approach. House, Haug and Norris (1996, p.139), in a study of evaluation practice in the US National Science Foundation, identify the importance of 'establishing an evaluation culture'. I would argue that educative evaluation is essential to a genuine learning society, but is antipathetic to the 'technocratic model' that Coffield argues underpins the rhetoric about the learning society in many European and UK policies (Coffield, 1998).

Evaluations nearly always have a second purpose: to satisfy the need for accountability for the spending of public money. Has the money been spent wisely, have the outcomes been sufficient in number and sufficiently high quality? Can the

programme be said to have been cost effective? The sub-agenda here is who should get the credit if things go well, or bear the blame if they do not go well? Accountability is always layered in a hierarchy of responsibility: the programme director and team(s) are held accountable for their work on the programme; and the officials who hired them are held accountable for choosing them for the job; politicians, in their turn, are held accountable for the actions of their officials; ultimately, accountability in a democratic state is to the electorate and politicians who are seen to preside over the waste of public money are unlikely to be re-elected. In the UK, there is a group called the Audit Commission which carries out evaluations entirely to serve the need for accountability. The focus of their work is entirely upon value for money and they claim an authority for their findings that is grounded in facts and figures, without taking account of the value-laiden assumptions that have determined what facts and figures should be collected (see e.g. Audit Commission, 1990, which present a case for closing small rural schools based on calculations which do not take account of the impact of closure of its school upon a rural community).

These two main purposes of evaluation are, therefore, in tension with one another. In order to learn it is important to acknowledge failures, as well as successes, and explore the reasons for both openly and honestly, but this will be difficult to do if individuals feel that their future careers will suffer as a result. Programme directors may not get further funding; officials may be side-lined or passed over for promotion; politicians may lose their seats in government. In practice, a lot depends on the prevailing culture set by those in positions of power. If there is a strong blame culture at the top this will be passed down the line and make it difficult to learn from the evaluation. If, however, those

at the top have trust in their officials and encourage open debate, they can set the tone for a learning culture that will permeate through all the levels. This analysis is too simple, since a strong personality in a powerful position can, to an extent, act as a protective layer against blame and enable a learning culture to grow among subordinates. There is also a role for an evaluator in mediating between sponsors and the programme team(s), providing explanations for problems, often in terms of the contextual factors such as policy decisions that have constrained the possibilities for action. My former colleague, Barry MacDonald, developed a model of democratic evaluation in which equal rights are accorded by the evaluator to all the participants (MacDonald, 1974). In democratic evaluation, successes and failures are explored in relation to the policies and structures put in place by the sponsors rather than simply in terms of the programme's outcomes. He found that this was frequently a surprise to those who had commissioned the evaluation, who assumed an alternative model of 'autocratic' evaluation in which those who hired the evaluator were themselves above judgement.

Another frequent reason for evaluation is largely symbolic. It may be a condition of setting up a programme that a proportion of the funds should be set aside for evaluation. In this case, the sponsors may not be greatly concerned with the evaluation's outcomes, provided there is a report and the evaluation can be said to have been commissioned and carried out. Alternatively, evaluations may be commissioned in order to promote the programme, and sponsors may expect the evaluator to engage in advocacy on behalf of the programme. Stake's article (op.cit) presents a case in which the sponsor had either one or both of these motivations.

It is common for evaluators to be led to believe that an evaluation has been

commissioned to feed into decision-making when, in fact, the decision-making time-frame is too short to wait for the evaluation report. If this is the case, interim reports or meetings with the sponsor part way through the course of the evaluation may be much more influential than the final report.

There are, in broad terms, two kinds of question which can be the focus of evaluations:

(1) questions which seek factual information

These questions start with words like 'how much/many ... ?' and 'how quickly ... ?' In terms of hardware and software development this kind of question includes: 'does it function ... ?' and 'how robust is it ... ?' These include questions asking people for their opinions, in order to find out how many people hold one opinion and how many hold another. The latter involve administering structured questionnaires (e.g. using lickert scales) to a representative sample which can be compared with 'a control group'. The resulting quantitative data can be analysed statistically (using probability theory) and the outcomes treated as facts, subject to a margin of error. These questions are designed to provide dependable, factual data to inform judgement. These data are sometimes called 'hard data'.

(2) questions which seek reasons and explanations

These questions start with words like 'why ...?' and 'how ...?' For example, 'how effective was this piece of software?' and 'what strategies for collaboration proved most successful and why?' These questions explore issues of quality and seek informed judgements and in-depth explanations. They are designed to generate data which can form the basis for explanatory theories. Data are normally collected using methods such as observation and interviewing or open-ended questionnaires. These data can be analysed using methods of qualitative data analysis, which will involve coding the data in some form and then interpreting the outcomes. Theorists of qualitative methods sometimes use terms such as 'theoretical sensitivity' (Strauss and Corbin, 1990) and 'sociological imagination' (Mills, 1959) to describe the most highly developed interpretative skills of the qualitative researcher or evaluator. These data are sometimes called 'soft data'.

Learning cultures which place priority on the educative purposes of evaluation give a higher priority to the second kind of question, whereas accountability cultures give a higher priority to the former. The terms 'hard data' and 'soft data' are primarily used by those who favour quantitative methods as a means of undermining the credibility of qualitative methods - who after all wants to base judgements on something 'soft'? If possible, evaluators should avoid relying completely on either one kind of data or the other - both quantitative and qualitative data are essential so that the evaluation can produce reliable information *and* robust explanatory theories. Arguably, without the latter an evaluation cannot be educative.

For various reasons politicians and policy-makers often place higher reliance upon quantitative methods. This is partly because there is always pressure on them to be able to claim certainty in justifying how they have spent public money, and they can do this more easily with research based on the methods of the natural sciences because they command a high level of public confidence. Quantitative measurements of empirical studies have enabled the amazing technological progress that has led to the production of CIT resources; and statistical analysis of large bodies of data collected in controlled, experimental conditions have produced knowledge about illness and the

human body which has revolutionise medical practice. However, a group of human beings interacting with one another to work collaboratively or learn new skills - say for example, a group of computer users - is subject to irrational responses and unpredictable behaviour in a way that the human body, as a functioning system, is not. The social sciences, of which evaluation is a sub-set, have adapted quantitative statistical methods to apply to group behaviour and human interactions, but the results of this kind of analysis are much less reliable than is often claimed (see House, 1980, p.71 who refers to the conclusions of an extensive study by Cronbach). It is particularly important to remember this when evaluating CIT initiatives because technologists may tend to privilege quantitative methods with which they are familiar in their own research. Paradoxically, qualitative methods may be essential to enable technologists to understand the complex emotional and cultural factors which make it difficult for non-technologists to become confident and competent users of technology (Somekh, 1989).

11.3. CHARACTERISTIC PROBLEMATIC FEATURES OF CIT PROGRAMMES

Evaluators need to pay attention to both the products of CIT programmes and the processes by which the programme teams carry out the work. For the products to be successful the team needs to work together effectively - as a genuine team. In this section I will address the following problems relating to processes and products:

(1) process problems

- collaboration
- mixed skill teams
- over ambition

(2) product problems

- delay
- lack of established communication conventions
- the medium constrains the content
- the halo effect and tolerance of poor quality
- inappropriateness to users

11.3.1. *(1) Process problems*

- Collaboration

Technological innovation, and its diffusion, reflects complex collaboration between different stakeholders, typically involving partnerships between the State, universities and business. (Cullen et al 1993 p. 117)

It is in the nature of technology projects that they require a high level of collaboration between disparate groups. The purposes of the state, universities and businesses are very different but they frequently come together to work on technology projects. The time-frames of politicians and businesses are shorter than those of academics, so there is a tension between the emphasis on short-term as opposed to medium to long-term goals. There are also issues of commercial secrecy, essential for business partners, which conflict with both the ideal of academic freedom and the obligation to share knowledge developed with public money provided by the state or the EU.

Collaboration is, in any case, a much more complex and difficult process than is generally recognised (MOHD, 1997). One of the great benefits and pleasures of working on EU programmes is the requirement to work as part of an international team. As Europeans we are culturally enriched and the strengths in terms of skills of each national group are made available to others through collaboration. Nevertheless, there is a price

to pay for these benefits of European integration. Teams often come together with little prior knowledge of each other. Usually one or two of the partners will have worked together in the past, but the others will be strangers. Even if we all spoke the same language - heaven forbid - there would be inevitable misunderstandings because meaning is constructed by groups on the basis of interaction and shared experience. Meanings become even less precise when the team is working in several languages on a day-to-day basis and operating at different levels of familiarity in an agreed common language for meetings and reports. There are also inevitable stresses in working together to tight deadlines to produce high quality 'deliverables'. There may be different expectations of what counts as quality, there will certainly be different understandings of how best to manage time. Overlaying the deep-rooted differences in national culture there are differences of research culture. One group may be more practical and pragmatic and focus wholly upon the contractual outcomes and deliverables; another may believe it to be essential to begin by developing the theoretical and philosophical knowledge upon which to base the practical work. Political ideology may also be a factor. In the UK between 1979 and 1996 we were led by a government that emphasised competition rather than collaboration and set the tone for a blame culture rather than a learning culture. For many of us this has made it a particular pleasure to work on EU collaborative projects, but we have also been unable to avoid our association with a country that has been perceived by other Europeans to be 'isolationist' and often 'arrogant' and 'difficult'.

- Mixed skill teams

To be successful, CIT projects in education need to bring together researchers and practitioners from different disciplines.

Software development is the province of software engineers and computer programmers; despite the increased availability of advanced software tools and libraries of routines there is and will continue to be a need for specialists who can maximise the power and flexibility of the technology. At the same time, the development of learning materials is the province of the educational specialist; what appears on the screen is the province of the electronic designer; and the content of the material is the province of a relevant subject specialist.

In practice, this means that individuals from different disciplines have to learn to work together. The social process of such projects is grounded in, and constructed by, conflicting paradigms and discourses. What Foucault says about society in general is equally applicable to groups working in specific disciplines with their own distinctive cultures:

> Each society has its regime of truth, its 'general politics' of truth: that is, the types of discourse which it accepts and makes function as true; the mechanisms and instances which enable one to distinguish true and false statements, the means by which each is sanctioned; the techniques and procedures accorded value in the acquisition of truth; the status of those who are charged with saying what counts as true.

These differences affect every aspect of the project from fundamental beliefs (e.g. what kind of research needs to be carried out) to day-to-day working practice (e.g. the frequency and purpose of meetings).

- Over ambition

Perhaps it is the rapid pace at which technology has advanced that leads to the unrealistic aspirations which`are often

characteristic of technology-based projects. The origin of the problem lies with the unrealistic demands of sponsors. Technological innovations are often seen as having the potential to bring about major change at the system or state level (Somekh, 1989a), and in this way they seem to offer the kind of high profile, system-wide, "magic solutions" so dear to politicians (House, 1974, pp.213-4). This phenomenon originates in the fact that technology projects are usually shrouded in a certain mystique. As Cullen et al. also point out, citing Mackenzie & Wajcman, 1985:

> "Technological innovations do not draw on an unbounded pool of knowledge available in society at large, but rather focus on an existing technological base which may reflect the goals and objectives of institutions." (Mackenzie & Wajcman, 1985).
>
> (Cullen et al 1993 ibid p. 117)

This dependence of technology projects upon specialist technological knowledge also makes it difficult for non-specialists to judge their potential at the stage of the grant proposal. In the highly competitive business of bidding for funding, the temptation to oversell the benefits of the proposed initiative is always strong. In the case of technology initiatives, because sponsors and the public in general are ill-informed, it is possible to succumb to this temptation and remain credible.

CIT programmes are, therefore, often in the position of managing the disappointment of sponsors as the work progresses towards completion. This phenomenon was particularly apparent in the first phase of the UK Teaching and Leaning Technology Programme in which some projects (but certainly not all) achieved considerably less than had been promised. (Coopers and Lybrand et al. 1996)

Another problem of over-ambition is that technology projects sometimes rely upon technology too much as a means of communication. Telephone systems in all the participating countries may not be adequate to meet the demands of the programme; hardware may be delivered late; software may take time to install; local needs may conflict with programme needs, leading to problems with differences in protocols, particularly with the transfer of files as attachments in electronic mail. Sponsors expect CIT programmes to communicate electronically and may reduce travel budgets accordingly. This can lead to serious difficulties.

11.3.2. *(2) Product problems*
- Delay (Cullen et al. ibid. p.xx)

What a programme director expects to be possible at the time of designing the research is often not possible when work actually begins. As long ago as 1984 I found out to my cost that if you ask most computer enthusiasts in general terms if they can do something they will say yes, but if you ask them again three months later to do it now they will say, well not now, tomorrow ... Things are always promised for the near future, but unexpected problems constantly arise and delay implementation. One reason for this is, of course, that it is unacceptable to work with yesterday's technology. Hardware and software rapidly become out of date, so it is a difficult challenge for a three year CIT programme to produce state-of-the-art products. This makes is essential to use the newest technology for development tools, but this makes the programme vulnerable to late delivery and/or software bugs. Installation also usually takes much longer than planned. Sometimes buildings have to

be adapted, electric wiring has to be changed, new furniture has to be purchased, telephone lines have to be installed. I have never yet evaluated a technology project which was not subject to some delay at its inception. In one case, involving colleagues rather than myself, the delay was so extensive that, combined with the unrealistic time-frame for the work set by the sponsors, some of the software products never reached user groups for trialing because they still did not run at the end of the funded period (Norris, Davies and Beattie, 1990).

• Lack of established conventions for effective communication

It is still much more difficult to design high quality learning materials for electronic delivery, via multi-media, CD-ROM, or internet, than it is to design paper-based materials. This may partly be because there is no notion of a professional publisher for electronic materials. The process of publication is incorporated with development and the product is produced by the development team itself. Perhaps it is hardly surprising that many of these materials lack professional polish in their finished form. However, the problem is a more fundamental one. A book or a journal follows an established format, the reader knows what to expect, the author can use established conventions such as chapters, bibliographies and indexes. More elaborate paper-based learning materials, such as those produced by the Open University in the UK, have been designed with the benefit of years of experience to be easy-to-use and readable, incorporating the right balance of text and 'white space'. By contrast we are still learning how to communicate effectively in electronic form. There are relatively few established conventions and we are still at the stage of exploration. The pull down menu, the hot button, the switch from pointer to hand as it hovers over the button, and the change of colour after a text button has been clicked on, all seem to be established conventions, but there are relatively few others. Developers are still experimenting with navigation systems to provide structures which are flexible without causing the user to get 'lost'; the interface between the software development tool and the learning environment it has created is often discordant; and there is little agreement about how much text it is reasonable to put on the screen. It is claimed that one of the great benefits of CIT materials is their interactive components in which the user engages with the materials which change in response to user-inputs. However, in practice it requires considerable skill to design interesting and challenging inter-active materials. We still lack sufficient models of how to do this in effective and varied ways. Indeed, the expectation that electronic learning materials will communicate with users effectively without the supportive intervention of a teacher is so far proving untenable in practice.

• The medium constrains the content

A major difficulty is the way in which the electronic medium constrains the way in which the content can be presented. This is partly to do with memory constraints and/or the slow speed of down-loading material from the internet. Text is less memory-hungry, text is quick, hence most learning materials mainly consist of text rather than diagrams, photographs or moving images. Rather more worrying, because more fundamental and long-term, is the way in which computerised tools for analysis impose a logic on the storage of information. There is a tendency to categorise information so that it can be sorted and counted, rather than storing it in an uncategorised form and using it holistically. There is also a tendency to produce text in screen-sized chunks with simplified vocabulary and syntax. The small

size of the screen is thus beginning to have the effect of creating a tabloid-newspaper-style of on-line communication, with a tendency to simplify ideas and concepts, and present them in a fragmented or partial way. This kind of reductionism is balanced by the ability to down-load whole documents for printing and it may be that screen-reading will never become the accepted norm for lengthy documents.

It is in the area of testing and assessment that the constraints of the medium are most apparent. CIT learning materials often have built-in assessment, but very few styles of format are possible. The only wholly satisfactory method which is reasonably simple to produce is the multiple choice question bank. These can be designed to test understanding of concepts at a deep level, but this requires the person setting the test to have considerable skills in test design as well as in-depth understanding of the subject matter. At present, many of the tests incorporated with CIT learning packages are rudimentary and simplistic. If this kind of testing becomes the norm it could have the effect of reducing knowledge to information, as predicted by Roszak (1986) and its acquisition to a technical process much less challenging to the learner than constructing knowledge - and fundamentally less educative.

- The halo effect and tolerance of poor quality

There are worrying indications at the present time of an explosion of materials on the internet. There is some evidence that this is leading to poor quality materials being accepted uncritically because of the medium in which they are being presented. The web has a halo effect which lends an unwarranted value and respectability to inferior products. Unfortunately, easy-to-produce electronic learning materials tend to be highly repetitive in format and dull to use. In many cases the authors could have produced far more interesting, better quality materials, in another media. Above all, we need to question whether it is feasible or desirable to conceive of the internet as a learning machine which dispenses in any way with the need for teachers. Some people are spending hours on the web, but it is not yet clear what they are gaining from doing so.

- Inappropriateness to users and inappropriate uses

The biggest problem for designers of CIT materials remains the difficulty of matching users' needs. This is a dual problem - partly one of judging the level of difficulty of the content correctly , but partly too of creating a user-interface that makes it possible for all learners to participate with ease and confidence. The computer environment remains a technological environment. The interface problem is still not solved. In the end, the lone user contributes the essential element to his or her learning that Gavriel Salaman (1992) calls AIME (Amount of Invested Mental Effort). CIT materials are more dependent upon AIME than most other kinds of learning materials because they are more likely to be used without the support of a teacher. It is always crucial to involve members of potential user groups in the development of the materials and to pilot their use with learners. In practice, many CIT development programmes find it difficult to do this effectively because they are working to a tight time frame and running behind schedule.

The quality of the learning materials is of paramount importance, but this can only be determined in relation to theories of effective learning. There is no one right theory, but too many CIT products are developed without taking account of *any* learning theory. Elsewhere I have reviewed some of

alt-j vol. 98
new technologies for higher
education

the learning theories that seem to me to be worth taking into account (Somekh, 1996). Another study by Koppi, Lublin and Chaloupka (1998) explores the role of technology in enabling five desirable learning outcomes: holistic appreciation of where the subject fits into a global context, active experiential knowledge, collaborative communication and team work, problem-solving and critical thinking, and control over one's own learning in order to become a life long learner.

Another problem for designers is that they have no control over the uses to which the materials will be put. Users may spend little time on those parts of materials designed for concentrated work; they may use strategies to accelerate progress on the task (e.g. giving deliberately wrong answers to test materials). In cases where the materials are mediated by teachers there is the possibility for investigative work to be trivialised (e.g. by the teacher partially supplying the answer); and when authoring tools are made available for use with open-ended resources, many teachers reduce the potential interactivity of the materials by creating electronic work sheets (Norris, Davies and Beattie, 1990).

11.4. A MODEL FOR EVALUATION TO ENSURE EXCELLENCE IN CIT PROGRAMMES

During the last twenty years considerable work has been done to develop robust strategies for evaluating programmes. In an early study, House (1980) defines eight separate approaches including 'systems analysis', 'behavioural objectives' and 'case study'. He does not recommend any one approach, but concludes (ibid. p.256) that, 'Public evaluation should be democratic, fair, and ultimately based upon the moral values of equality, autonomy, impartiality, and reciprocity.' Ultimately evaluation is about making value judgements but doing so

on the best possible evidence. After thirty years experience, Cronbach came to the conclusion that:

'The evaluator should almost never sacrifice breadth of information for the sake of giving a definite answer to one narrow question. To arrange to collect the most helpful information requires a high degree of imagination, coupled with the flexibility to change plans in midstudy.'

(Cronbach, 1982, p. xii)

Currently, there is a preoccupation with the tension between the educative and the accountability purposes of evaluation that I referred to in the first section of this paper. McEldowney (1997, p. 176) refers to these as the 'control' model and the 'helping' model of evaluation. He explores the concepts of 'deadweight' 'displacement' and 'additionality' as means of judging the value for money of a programme, but concludes that although this is a useful approach:

'(it is) often without regard to the difficulties and limitations that exist in measuring these concepts' (and is often at the expense of) 'a consultative style where a transfer of learning should occur based on timely feedback to program managers about the effectiveness of paticular interventions or measures and about the achievement of the objectives set for the program in question.'
(McEldowney, 1997, p.186)

Those who see evaluation as primarily an educative process place emaphsis upon its utilisation (Patton, 1986). Others such as Stake (1998, p. 203-4) see their role as

'finding and understanding quality' and warn against becoming 'collaborators in redevelopment.' The tension between these two approaches is now one that evaluators frequently need to address, since currently there is considerable interest in approaches to evaluation which take into account the needs of multiple stakeholders (Somekh, 1997).

Some of the most interesting recent work has reported on various approaches to evaluating multi-site programmes. In the case of European Social Fund programmes, evaluators have the opportunity of looking at similar initiatives implemented in different countries, with the possibility of determining the effects of adopting different strategies. Barbier and Simonin (1997, p 396) look at two levels of implementation: 'the political, administrative and financial level' and 'the street level' but cite Hall (1996) in concluding that comparisons are difficult as 'all actors involved have objectives of their own; the more numerous they are, the more objectives and points of view there are.' In the case of CIT projects funded by the EU each partner normally contributes in different ways to each work package and takes responsibility for different deliverables. Nevertheless, there is potential for much greater depth of understanding when working with more than one partner. Large-scale multi-site evaluations require good organisation and good communication. The numbers of partners involved at meetings can pose evaluators with problems, hence some evaluators have developed tools for structuring discussion and consultation (Beywl and Potter, 1998). The Kellogg's Foundation's 'cluster evaluation' approach is of particular interest. It has four key characteristics:

1. It looks for common threads and themes across sites.

2. It seeks to learn why things happened as well as what happened.
3. It is highly collaborative, encouraging all players to participate.
4. It maintains confidentiality between the external evaluators and the projects.

(adapted from Worthen and Schmitz, 1997, p. 303)

Building upon all these ideas, I want to put forward a case for evaluation as an essential, integral component of achieving excellence in innovative CIT research and development programmes. The case assumes a particular model of evaluation which presupposes the following principles, goals and contributions.

(1) Principles of the evaluation

The evaluation should:

- build trust with the team(s)
- remain independent of the team(s) and other stakeholders
- operate within agreed ethical guidelines

(2) Aims of the evaluation

The evaluation should:

- identify and address the various purposes of the evaluation
- address both the formative and the summative aspects of the evaluation
- meet the needs of stakeholders
- generate both quantitative information and explanatory theories

(3) Contributions of the evaluation to the development of the product

The evaluation should:

- alert the team(s) to what has been learnt from previous projects of a similar kind

alt-n/w/aner/. 98
new *.echnologies for higher*
education

- monitor progress on the multiple tasks of the programme
- provide feedback on the products as they develop
- trial products with users, thereby assisting the programme to meet user needs

(4)   Contributions of the evaluation to the working process of the programme

The evaluation should:

- mediate between the programme team(s) and multiple stakeholders
- mediate between team members where differences in attitudes and values exist

11.4.1. *(1) Principles of the evaluation*

- build trust with the team(s)
- remain independent of the team(s) and other stakeholders
- operate within agreed ethical guidelines

Evaluators are in a position of power in relation to the programme director and team(s). Their access to information and the quality of the information they collect is dependent upon establishing trust. They need to form good working relationships with the director and team(s) so that they have access to the informal, as well as the formal, working processes of the programme. Evaluators need to understand problems. In my view their privileged position places them under an obligation to provide advice and assistance where they can, within the limits of their remit.

At the same time, evaluators are only useful because of their independence. They need to maintain a distance from the programme director and team(s). Striking the right balance between independence and informality is important. In my experience you need both with some markers to distinguish between different purposes for different occasions. Once trust and informal relations have been established it can be helpful to formalise some of the data collection events and meetings, perhaps by linking them to formal written feed-back.

The evaluation must operate within clear ethical guidelines which give all concerned control over access to information and its clearance for publication. It is best to negotiate these guidelines with the programme director and team(s) early in the life of the project and circulate a written statement. The team(s) needs to be assured that any written reports will be fair and accurate, that they will be asked to comment on draft reports and play a part in improving their fairness and accuracy, and that where they disagree with an interpretation made by the evaluators they will have the right to have their own alternative views included in the report. The guidelines have at least three purposes:

- to ensure that the evaluation is able to report fully and fairly on the work of the programme
- to protect the rights of the programme director and team(s) and place reasonable limits on the power of the evaluators
- to ensure that the evaluators have access to full information, without the team(s) feeling the need to conceal anything potentially damaging.

11.4.2. *(2) Aims of the evaluation*

- identify and address the various purposes of the evaluation
- address both the formative and the summative aspects of the evaluation

edmedia/ed-telecom 98
new technologies for higher
education

- meet the needs of stakeholders
- generate both quantitative information and explanatory theories

It is very important for the evaluators to begin by exploring the various purposes of the evaluation, to ensure that they are able to address any purposes that may have been intentionally or unintentionally concealed as well as stated purposes. This enables evaluators to clarify the time frame for decision-making so that they are in the best possible position to influence future policy. They can also decide on the balance to be struck between the formative and summative purposes of the evaluation. e.g. if the purpose of the evaluation from the sponsor's point of view is mainly symbolic, there is little point in placing the main emphasis upon a detailed summative report; instead time can be better spent on producing formative feed-back for the team(s).

Evaluations are always politicised, sometimes strongly so. The development of policy for CIT in education is contested because it is costly and because it is often the source and focus of aspirations. Power is exercised at different levels. Evaluators need to make judgements about the extent to which different players have power and monitor the shifts in the political context. e.g. sometimes a report may have more impact if it is produced by a particular date.

Inevitably, therefore, evaluation is itself a political activity. It is better to acknowledge this than try to ignore it. Evaluation is an inherently moral activity that involves the evaluator in wielding power, however large or small, according to ethical principles (see the previous section).

Programmes developing CIT for education always have multiple stakeholders, including national or EU policy-makers, the programme team(s), commercial partners and users, including teachers, students and local policy-makers. All these stakeholders have rights and all are likely to have different needs. It is a matter of democratic principle to address all their needs; but it is also a matter of professionalism and efficacy, since the stakeholders all have the potential to assist or to block the take-up of products.

Depending upon the purposes of the evaluation and the needs of the various stakeholders, the evaluators will need to make different judgements on the right balance between quantitative measurement and the development of qualitative understanding. However, it is my view that an evaluation which relies solely on either quantitative or qualitative data cannot fully meet the needs of all the stakeholders. There is a duty to provide both factual information about, and explanations for, progress/success that can provide the basis for future action. In the same way, there is a duty to include both formative and summative elements in the focus of the evaluation.

11.4.3. *(3) Contributions of the evaluation to the development of the product*

- alert the team(s) to what has been learnt from previous projects of a similar kind
- monitor progress on the multiple tasks of the programme
- provide feedback on the products as they develop
- trial products with users, thereby assisting the programme to meet user needs

It is not always recognised that the evaluators are in the position of being able to make contributions to the programme in various ways. I would go further and say that I think it is the duty of the evaluators so to do. I think this is always the case, regardless of the focus of the programme initiative, but

it is particularly important with CIT programmes because of their complexity and the wide-ranging demands that they make on the programme director and team(s). Evaluation is, in any case, an intervention: it will make an impact of some kind on the programme, so it makes sense to acknowledge this and ensure that it is a positive impact.

Inevitably, the evaluators are in a position to provide the team(s) with useful information and advice from the benefit of their experience of working with other similar programmes. They can only be useful in this way if they have established trust and close working relationships with the team(s), but this should always be the aim.

The evaluators can also help to maintain the balance of activity between the multiple tasks of the programme: the separation of these tasks means that individuals are often working in isolation; the programme director may be more interested in some aspects of the work than others; and personality differences between team members may give some tasks more impetus than others. The evaluators' monitoring function can help to keep everyone equally motivated and evaluators can also serve a useful role in keeping different partners aware of the work being carried out by others. This is particularly useful when dealing with several teams engaged in different aspects of a large programme.

Honest feed-back is of enormous value to programme directors and teams. My own preference is for very open preliminary feed-back within a confidential framework that ensures that the focus is upon learning rather than upon judgement. I often distinguish between a draft report that I feel will make a good preliminary discussion document with the team(s) and the report that ultimately I

write for publication. They have different purposes and can be dealt with differently.

The evaluator often acts as a broker of judgements on the products through collecting a range of data including stakeholders' perceptions. They can observe usage, interview users, count frequency of use, issue questionnaires, as well as trying the product out themselves as users. They have a particularly important role in feeding information back to the team(s), especially if the different stakeholders have different responses. Because of their relatively powerless position, students' views may be given less credence without the mediation of an evaluator. Without the evaluator they might not even have been asked for an opinion, but their views may be the ones that are most critical to the eventual success of the uptake of the product.

11.4.4. *(4) Contributions of the evaluation to the working process of the programme*

- mediate between the programme team(s) and multiple stakeholders
- mediate between team members where differences in attitudes and values exist

Evaluators can also make very helpful contributions to the working processes of team(s). CIT programmes are pressured working environments. Deadlines have to be met; there are likely to have been delays; team members have their own purposes which are not necessarily the same as those of the sponsor, nor indeed of each other; they are usually working with the uncertainty of a fixed term contract and future employment may depend upon pleasing the sponsor or pleasing the programme director (which are not necessarily the same thing). When colleagues are working under pressure misunderstandings can easily arise and evaluators can play a positive role in team

building. Likewise, the programme director will be working under stress: responsible for delivering to target, needing to ensure that the reputation of the university remains high, mindful that national policy-makers will be watching the outcomes of the team's contribution to the EU collaborative project. Evaluators need to be good listeners and act as mediators between the programme director, the team(s) and various stakeholders, or between different members of the programme team(s). This again underlines the moral nature of the evaluator's role. They are in a position of trust and must act responsibly.

Having set out my own ideas for the kind of evaluation that could enable excellence in CIT initiatives, I want to ensure that no one goes away under the illusion that I have found a definitive answer. Evaluation is a fascinating, socially useful, morally demanding and highly politicised activity. Its future in Europe depends upon the uses we put it to, and the role it is given by sponsors and politicians. As Ernie House says in the introduction to his book, *Professional Evaluation*:

> Evaluation has been shaped and continues to be shaped by powerful and complex social forces. Exactly what shape the institution, profession, discipline, and practice will take in the future is impossible to predict. What is clear is that the fate of evaluation will be bound to the government and the economic structure and will be determined in part by its own history and traditions. Part of the destiny of evaluation lies within the control of evaluators themselves; part does not.
>
> (House, 1993, p. xvi)

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new technologies for higher
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12. MODELING A WEB-BASED EDUCATIONAL ENVIRONMENT

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Abstract **- The advent of the Internet has brought about an immensity of opportunities for educational innovation. Many people, all over the world, are attempting to explore the inherent challenges. However, most of them tend to merely concentrate on content. Our belief is that there is no real future in content if context is not carefully taken into account.**

This paper aims at stressing the importance of context – a much neglected core component of Web-based educational environments –, relating it to some key concepts proposed by Vygotsky, Argyris and Senge.

To this end, we present some of the learning activities that can be explored in Web-based environments, we relate them to the main learning philosophies and associated cognitive and affective competencies, and we propose a model for the representation of educational intranets that borrows the UML notation from Software Engineering and takes into account both content and context.

12.1. INTRODUCTION

Since the emergence of the World Wide Web, efforts have been made so as to use it for educational purposes. Nevertheless, almost all these efforts consist on the mere transposition of the old teaching models to the Web. This does not only misuse Web capacities, but also explores activities in ways that are inappropriate for the Web environment [4]. Yet, the emergence of the Web "may well lead to redefining formal educational activities" [3].

Another aspect to take into account is context. In spite of all that has been said, content is not everything, and may even not be the most important component of an educational Web page. When not integrated with adequate context, content may end up producing just ephemeral results. This is in full agreement with Vygotsky's proposals of twenty years ago [10], that tells that knowledge acquisition is facilitated by social interaction, and that interacting with the environment and with peers fosters the internalization of development processes [6].

Argyris and Senge have equally stressed the importance of interaction and proposed the creation of learning communities [2,8]. They described those communities as privileged spaces for sharing ideas in ways that facilitate a more solid construction of individual knowledge and the appearance of a valuable collective wisdom. Those communities are characterized by a shared vision, a group of rules of conduct, and guiding values.

With the aim of promoting the creation of such learning communities on the Internet, we present the idea of an educational *intra*net: a reserved space of interaction where people can get together and share a common context where they can learn.

To this end, we suggest some educational activities and we relate them to the learning philosophies they support and to the competencies they help developing. After that we present a possible representation of

an educational *intra*net making use of the Unified Modeling Language (UML).

12.2. ACTIVITIES, LEARNING PHILOSOPHIES AND COMPETENCIES

A large number of educational activities have been identified, over the years, as being particularly suited to fulfil the aims of learning. Neves and Figueiredo [7] have emphasized and described the following:

- Case Studies;
- Debates;
- Directed Dialogues;
- Games;
- Panel Discussions;
- Problem Solving;
- Projects;
- Question Posing;
- Role Playing;
- Simulations;
- Small Group Discussions;
- Socratic Dialogues;
- Storylistening;
- Storytelling;
- Tutorials.

Even though they were all created for classroom purposes, they all lend themselves to exploration in Web-based environments, and some may even benefit from the shift. Indeed, the Web facilitates the creation of communities at a global level, it makes possible the access to large amounts of information, and offers the opportunity to interact with other users in synchronous and asynchronous ways.

Of course, choosing an activity also involves taking conscience of the competencies we wish to develop. We suggest the following [7]:

- Application *(Bloom, Foley)*;
- Argumentation [7];
- Autonomy *(Hunt)*;
- Comprehension *(Bloom, Foley, Orlandi)*;

- Conflict Resolution *(D'Hainaut)*;
- Creativity *(Kamii)*;
- Critical Thinking *(Foley, Orlandi)*;
- Curiosity *(Kamii)*;
- Decision *(Palkiewicz)*;
- Execution *(Foley, Orlandi)*;
- Group Work *(Hunt, Orlandi)*;
- Interest *(Burns, Foley)*;
- Leadership [7];
- Listening Ability *(Orlandi)*;
- Research *(Orlandi)*;
- Responsibility *(Orlandi)*;
- Synthesis *(Bloom)*.

Independently from the competencies they foster, activities may also be chosen or analyzed according to the learning philosophies they support. Indeed, each one is based on different principles and assigns different roles to the learners.

Action learning - "learning requires action and action requires learning" [6]. Groups are created in order to accomplish some task. To do so, they need to learn.

Conventional teaching – This follows the instructor-centered paradigm. The instructor presents the learning material and evaluates students through tests and exams.

Incidental learning - "Learning happens whether we pay attention to it or not" [1].

Learning by design - To learn by design we accomplish some task that involves abstraction and an integrative approach.

Learning by doing - "There is really only one way to learn how to do something and that is to do it" [9]. Learning by doing is acquiring knowledge by accomplishing some simple tasks.

Learning by exploring – Knowledge is acquired through an autonomous search for information.

Learning by reflection - Learners are encouraged to reflect about the way they think when solving a problem and to compare their way of thinking with that of experts and of their peers.

Learning by teaching – Learners play the instructor's role, teaching the others.

Learning from mistakes - "When the outcome matches our expectations, we don't learn a great deal" [9]. This is about using our mistakes as a way to improve our knowledge.

Situated learning - "Knowledge and skills are taught in contexts that reflect how the knowledge will be used in real-life situations" [6].

In a previous paper [7], two maps have been made of the relationships between learning activities and the learning philosophies they support, as well as between learning activities and the competencies they develop. From those tables, some inferences can be made.

For instance, in spite of everybody's' disagreement with *conventional teaching,* this philosophy is shown to play a very important role in today's learning processes, even on the Web. *Tutorials* are also identified as being a very easy way of teaching through the Web, although they do not seem to be very successful in the development of competencies. *Autonomy*, *comprehension*, *critical thinking*, *listening ability* and *synthesis* seem to be the only competencies to be enhanced by *tutorials*, and even so in a rather moderate degree. *Storytelling* and *storylistening* are very specific activities, since they tend to be used exclusively with children, and this may explain their reduced employment.

The proposed activities try, above all, to enhance *application*, *comprehension*, *critical thinking* and *interest*. Also, learning by reflection is the philosophy most supported by the activities listed.

Among all those activities, *project* and *problem solving* are the ones that lead to the development of a broader range of competencies, which suggests their special relevance for the learning process in Web contexts. *Simulations* and *small group discussions* should also be mentioned because of their completeness.

12.3. THE INTRANET

Designing an educational intranet involves many responsibilities. Its structure and its contents must be carefully chosen and thought out. Representing the intranet through a commonly accepted language does not only make possible its analysis by the designer, but also by all stakeholders of the process. Moreover, the usage of a standard language is the best way to facilitate discussion and incremental improvement while providing the architectural framework for implementation. The language we chose for this purpose is the Unified Modeling Language (UML) because of its increasing popularity and particular suitability to satisfy the above objectives [5].

Our first step was trying to represent the architecture of an educational intranet using a class diagram. In that diagram we considered each HTML page as a class. In such a diagram, a class is characterized by its attributes and also by its operations. So, the first thing to do is to identify those elements. In the case of an HTML page, the attributes (what uniquely identifies a page) are its content, images, background, and the elements of the forms it may contain. Indeed, these are the obvious attributes, as each one has a value, a type, and a visibility. Also, their values can be modified through some operations. However, when describing at high level the representation of an intranet, the inclusion of information regarding background and

images will only add confusion. Thus, our description will be restricted to the content of the pages and to the elements of the forms that they may include.

On the other hand, operations are the links that provoke jumps to other pages and the form's buttons that cause some kind of

into account the definitions of attributes and operations given by Fowler and Scott [5], we have decided to consider them as attributes or as operations depending on the level of interactivity they involve. If an activity demands some kind of local interactivity,
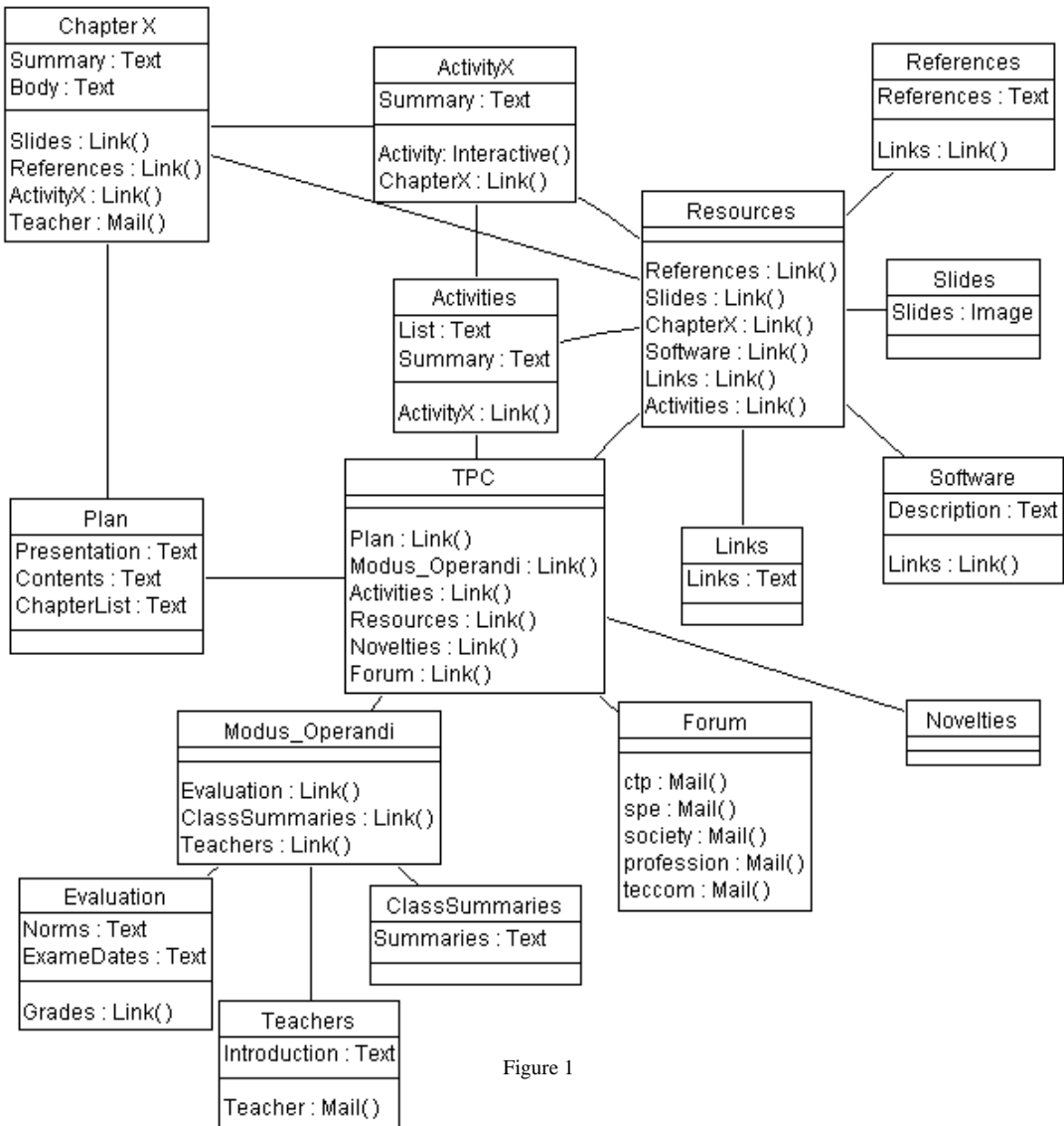
Figure 1

action.

With this in mind, we need to decide about where the learning activities belong. Taking

we consider it as an operation; if it only requires off-line work, then it will be considered as an attribute.

Figure 1 represents a class diagram describing the intranet we have created for a course in Technical Professional Communication (TPC). In this representation we have only considered some of the elements: texts, links, activities and mail.

How do you classify your understanding of this chapter?

Figure 2

In order to clarify our abstract representation, suppose we have an HTML page where a chapter is presented to the learner. This page starts with a brief description of the chapter, followed by its body. To practice and explore the material taught, the page offers a *simulation* activity where the learner is given the opportunity to change some values, immediately seeing the consequences. After that, the learner can jump to a page of links related to the chapter and is allowed to send an e-mail message to the instructor. At the bottom of the page, a form lets learners classify their

understanding in a 1-to-5 scale (Fig. 2). This classification is then sent to the instructor.

Figure 3 is the class diagram of this fictitious page and adds to figure 1 some form elements.

12.4. CONCLUSION

This paper offers an approach for the creation of an educational intranet. The objective was to stress the importance of a correct choice of learning activities, that can be used as the context for the exploration of educational content, while accounting for the competencies we wish to develop and the modes of learning we wish to explore. The paper also presents, though in a sketchy manner, the first steps of an abstract representation of educational intranets that takes into account both the content and the context of learning. This representation resorts to the UML notation and is currently in the process of being improved through further research.

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13. HOW TO USE INTERACTIVITY IN AN EFFECTIVE WAY: A PROPOSAL

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Abstract - **The effective application to teaching of Information Technology can help to reduce some of the problems that presently arise in the educational system. Indeed, the development of interactive tools can somehow fulfill the empty space left by the decrease of direct interaction between the student and the teacher.**

New approaches to the conception of educational materials must be considered as a new factor arises when one is dealing with automated learning processes – the Interactivity.

This paper describes some aspects related to the conception and development of a Computer Assisted Learning (CAL) environment, presently used in an introductory course in Pascal Programming at the University of Aveiro.

13.1. INTRODUCTION

"...in general, classrooms today resemble their ancestors of 50 and 100 years ago much more closely than do today's assembly plants, scientific laboratories, and operating rooms. A number of information technologists point out if business organizations today evolved at the same rate as schools, they would be still using quill pens instead of electronic word processors."

"Congressional Office of Technology Assessment"[1]

Lectures' overall organisation has remained mostly unchanged during the past few decades. Intensive use of the blackboard and the overhead projector to supplement the teacher's explanations are still the most popular aids. These 'static' means of exposition are sometimes quite unsatisfactory, specially when one is dealing with dynamic aspects, as it is often the case in Computer Science.

Study elements still use the same medium format of the past. The distribution is mostly based on books, class notes and exercise sheets, which make difficult for many students to play an active role in their learning process, since discussion of ideas does not come straightforwardly. In this sense, matters are even getting worse presently because of the decrease of direct interaction between the student and the teacher due to the increase of student population.

Advances in Information Technology of the past decade may help to change significantly this scenario.

The availability of low-cost, yet very powerful, computer platforms with extensive multimedia support, and of very sophisticated authoring tools makes possible today the development of interactive learning environments that can solve in part the problems described above.

However, the application of information technologies in this area has not been much effective up to now. Thus, it is very important to look for new ways of introducing the computer in the learning process so that in the future it may play a role as relevant here as it now plays in industry and in the services.

This paper discusses some aspects related to the conception and development of a Computer Assisted Learning (CAL)

environment, presently used in an introductory course in Pascal Programming ("Programação, Estrutura de Dados e Algoritmos" - PEDA), at the University of Aveiro.

13.2. PROBLEM SOLVING ORIENTED TUTORIAL

The environment is organised in a set of modules, each discussing a specific point. Presently available modules deal with the basics of computer organisation, algorithm description and program development and testing, top-down design using a procedural approach, and static data structures based on arrays, strings and records [URL1]. A complete description may be found in [2], where implementation aspects are discussed in detail.

Strong emphasis is put into developing the students' problem solving skills. So each module can be regarded as a succession of theme presentations, designed according to a 'problem solving oriented tutorial' model.

Theme presentation typically starts with the discussion of a case study, a simple problem whose solution needs the new concepts to be introduced. As the student goes along, key questions are put and exercises are presented to help to find the way to the solution. Then, the student is challenged to switch to a programming environment to run and test the solution.

This approach, which we believe is new, aims to explore the multimedia facilities provided by the authoring tools in order to make the student an active participant in the process and to ensure a good interconnection between programming theory and practice. In many cases, the answer to a particular question is mandatory to proceed. Thus, life is not made easy for those who are only interested in reading the information provided.

13.3. THEME PRESENTATION

Teaching the first programming language raises some specific problems that are not easily solved. While syntax rules are usually simple, the description of problem solutions in a formal language requires thought abstraction, discipline, creativity and a total care for detail. These are features which human beings do not extensively use in day to day communication.

To overcome these difficulties, one has inevitably to practice a lot so that ones style may be improved through trial and error. This spirit can hardly be conveyed by exposition alone. Hence, the mere presentation of full worked out examples is a poor approximation to the learning process. The student can easily be deceived about his (or her) own capabilities in solving new problems.

A pure explanatory approach is good enough when one deals with programming language syntax aspects. Beyond that, to be
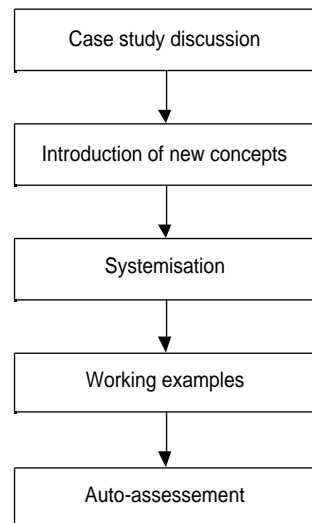
Figure 1 – Basic steps of theme presentation

effective, one has to intermix the discussion of language constructs with the development of solutions for particular cases, much in the

same way as it is done in the classroom, if one expects to keep the students full attention and participation.

The diagram of figure 1 shows how theme presentations were divided in order to carry out these ideas. They will be now illustrated through examples taken from the 'Arrays' module.

13.3.1. *Case study discussion*

Each new theme presentation starts with the discussion of a case study. To increase students' motivation, examples from sport or music are normally selected.

In general, previous knowledge is not enough to write a formal description of the solution of the problem. So, questions are asked to make the student gradually aware of the need of new concepts. We try in this way to catch the student attention to the issues being discussed and to find the exact timing where the new concepts may appear as fundamental, or very useful, to the solution being sought.

Figure 2 shows the first frame of the description of the problem that is discussed at the beginning of the chapter about sorting. To emphasise how important sorting algorithms are, the student is invited to imagine how hard his (or her) job would be

if he (or she) had to look for his (or her) PEDA score in a 2000 - random organised entry table.

The matter is further elaborated by trying to ascertain what are the basic operations that a human being carries out when is informally ordering a sequence of values. Through a question the student has to answer, the need for a procedure that finds out the sequence element that has the smallest value is pointed out.

13.3.2. *Introduction of new concepts*

As was mentioned before, one aims at making the student an active participant in the learning process. Thus, we try whenever possible to present the issues in an interactive way.

According to this strategy, questions are asked and the student is requested to carry out exercises that may elicit the points to be made. At the same time, taking advantage of the multimedia capabilities of the present day PC's, simulations are presented to improve the grasping of the new concepts.

Figure 3 shows an exercise that follows this reasoning. The student is requested to find out a procedure to determine the sequence

Figure 3 – Introducing new concepts through a hands-on strategy

element that has the smallest value. The initial positions of the light and the dark

Figure 2 – Describing the problem to be solved

pointers were selected by the student in a previous exercise.

The hidden sequence values are randomly generated at the start of the exercise, so they are always different and unknown at each instantiation. Using the named buttons, the student may change the pointers' position and compare the element values pointed at. In this way, a solution may be determined. To be considered correct, it has to be carried out in a minimum number of steps and to ensure that the light pointer points to the smallest value element.

When it is complete, the student solution is automatically tested by comparing it step by step with the built-in algorithm. If something is wrong, a message appears in the screen pointing out the step where the error has occurred and why is wrong. The student may then proceed from that point on.

13.3.3. *Systemisation*

Once, the main ideas are understood, generalisations are made and the matter is discussed again using in general a different approach.

CAL has unique potentialities for teaching programming languages due to its inherent capability of describing dynamic processes through animation.

To describe the running of a program is not an easy task if one is using the blackboard or the overhead projector. The executed instruction stream is not usually fixed and depends strongly on data input at each run. Thus, the description becomes rather complex and confusing after the first few instructions, making it very difficult to keep track of the variables values.

However, by using in a systematic way the features of the adopted authoring tool (Authorware by Macromedia [URL2]), it became possible to create credible simulations of the running of programs. Data could even be inputted in a similar way as it is done when the program is actually

executed. Besides getting the output, the student could also follow step by step the sequence of executed instructions and the changes in the variables stored in memory.

In figure 4, we can appreciate what the student would get after finding a valid

Figure 4 – Merging of different ways of looking at the running of a program

solution for the selection sort algorithm. Again, to make the simulation more effective the sequence of values is randomly generated at the start of each run. The instruction presently being executed, the changes in the variables, the test of particular sequence elements and the way values are being swapped in the sequence can all be seen at the same time to provide a better understanding of what is happening.

13.3.4. *Working examples*

Following the old saying that 'one only learns, when one actually does the work', the student is invited next to switch to the programming environment (Turbo Pascal for Windows [URL3]) to compile and run by him (or her) self some coded examples and to perform changes in them.

To make the integration of environments as natural as possible, the switch is performed by pressing a button located at the navigation bar. Figure 5 shows a general view of what one gets.

Figure 5 – Switching to the programming environment

This approach has taken the following aspects into consideration:

- at the end of each example, a list of the whole program is provided to allow for the case where the student has not installed Turbo Pascal in the platform where he (or she) is running the environment;
- upon exiting Turbo Pascal, control returns to the environment exactly at the point where the environment switch was made so that the student may go on without further ado.

This strategy enables the student to get easily acquainted with the programming environment he (or she) will be using and stimulates him (or her) in actually running and modifying the programs, which otherwise might not happen due to the time needed to input the source code from scratch.

13.3.5. *Auto-assessment*

In the final stage of the learning process, the student should be given means to assess what he (or she) got out of it. So, lists of exercises deemed suitable to each instance are presented and the student is requested to answer them.

Without them, it is very difficult for the student to have a clear idea if progress has been made and what are the weak points that require further study. Ideally, one would like that he (or she) could get information of the same quality as provided by a human assisted tutorial.

However, contrary to other environments described in the literature [3-4], [URL4], we decided not to keep permanent records of the student performance so that he (or she) could feel totally free to express his (or her) reasoning without fear of being marked.

Figure 6 shows the auto-assessment exercise that appears at the end of the chapter about sorting. It makes a revision of three sorting algorithms (selection, sequential and bubble) through the analysis of slightly different versions of those previous studied. The student is expected to be able to identify the algorithm type, the sorting being performed (increasing or decreasing), the direction of search and the element value to be looked after (smallest or largest).

Figure 6 – Example of an auto-assessment exercise

13.4. CONCLUSION

The availability of low-cost, yet powerful, computer platforms with extensive multimedia support, and of very sophisticated authoring tools is opening the educational market to a new class of products: Interactive Learning Environments. To take full advantage of the

opportunities, one has to devise means to deal successfully with interactivity.

Being a new area, where previous experience is scarce, the design of interactive learning environments is not trivial. In this paper, a model we call 'problem solving oriented tutorial', is described. We believe it may prove an useful aid in developing this kind of environments.

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14. SIMULATIONS FOR FACILITATING SELF-TRAINING IN FLOW CYTOMETRY - DISCUSSION OF THE CONCEPT AND ITS UTILITY

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Abstract **- Presently there is a real need for specific learning and training programmes in analytical cytology or cytometry. An important reason is that, for reaching its main goal, this discipline is using sophisticated instrumentation like flow cytometers. In fact there are some difficulties a trainee, wishing to learn and use flow cytometry and its methodologies, may face: i) in many countries the number of cytometers available is still low ii) in many laboratories they are intensively used in basic and applied research projects, so the time left for training is limited iii) because training implies experienced trainers and is time consuming it is not easy to find laboratories and experts available for training iv) the use and maintenance of flow cytometers is quite expensive. We believe that the development and use of simulations in this field, as in many other fields, can facilitate the process of learning. Therefore we decided to design and develop a flow cytometer simulator. A virtual flow cytometer can help to solve some of the above mentioned difficulties i.e.: i) the trainee can use it where and when he/she wants ii) understanding more easily the basic principles and the modes of getting more from the instrument iii) at the cost of a PC, with wrong operations having no consequences. In this paper we discuss the design and development of a prototype of such a tool, which is under development for Windows platforms and it is meant to be used either directly by the trainees or by developers of hypermedia courseware for producing simulations which can be integrated in their courses. It should also be possible to use this simulator through the Internet or the Intranet of an institution like a school.**

14.1. INTRODUCTION

The fast evolution, on one hand, of Analytical Cytology or Cytometry (CM) as a discipline and, on the other hand, of the subjacent laboratory technologies and methodologies, is requiring more than ever, active learning and training, not only by the trainees but also by the trainers.

The main goal of CM is to develop methods to be used with progressive and sophisticated technology, under the form of cytometers, in order to perform global multidimensional measurements on cell populations (or cell organelles), based on determinations in each individual member of the population, more and more specific, sensitive, precise and reproducible, i.e.: more and more accurate.

Flow cytometry (FCM), one of the possible approaches to achieve the goal of CM, uses the knowledge acquired in the last 20 years in such diverse areas as optoelectronics (lasers), electronics of sensors (photodiodes and photomultipliers), fluorophores chemistry and computer hardware and software.

FCM allows fast simultaneous measurements of cell parameters (characteristics) , began in the seventies and is currently used in a great number of areas in medicine (immunology, pathology, etc.) and biology. Its use has been increasing in

the last years and this trend will probably continue in the near future [1,2].

Training people to use flow cytometry is a very hard and time consuming task, since it is a difficult technique to use in its full extent and benefit. Thus the need for great commitment on the part of the experts who act as teachers. This training is very expensive because of the high costs of flow cytometers and the fact that users are usually widely distributed geographically sometimes far from the main training centres. Efforts to facilitate learning and transfer of knowledge are being developed through the production of videos, placement of specific information on the WWW and lately with the edition of CD's [6-13]. As in other areas where simulators are currently being developed and

development for Windows platforms. It was designed to be used not only directly by students or teachers in self-study or guided training sessions but also to produce simulations which can be integrated in hypermedia courseware. The possibility of making this simulator available over the Internet is also under consideration since it would make it more accessible for geographically dispersed students.

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14.2. FLOW CYTOMETERS: COMPONENTS AND FUNCTIONAL CONCEPTS

</div>

Flow cytometers are instruments able to measure many structural and functional, either intrinsic (the cell does not need to be treated) or extrinsic (the cell needs to be
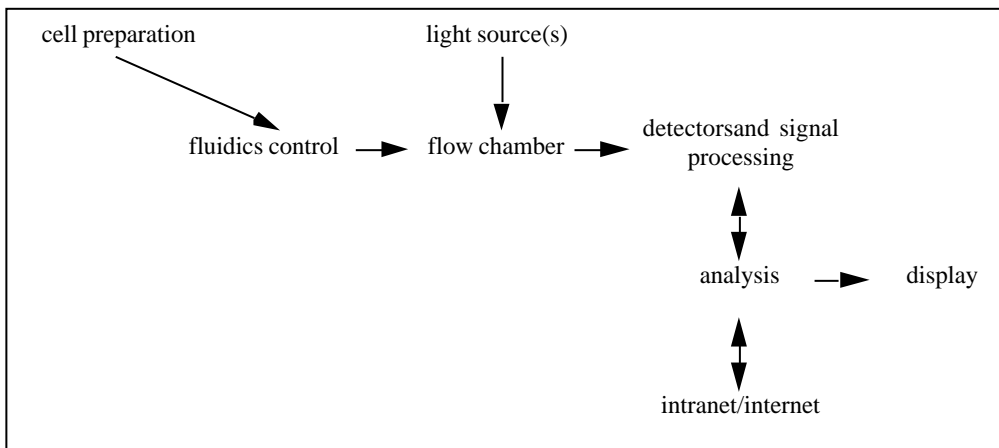
Figure 1- Schematic diagram of a flow cytometer internal organisation (adapted from Phillip N. Dean, Overview of Flow Cytometry Instrumentation *in* Current Protocols in Cytometry (1997) 1.1.1-1.1.8, John Wiley & Sons, Inc.)

used with interesting results [3, 4, 5], the existence of simulators, as well as self study courses that could be used by all the trainees, could significantly decrease the institutional effort needed to train flow cytometry users. This would be possible due to the decrease in the time that students need to use the equipment, the help they need from their teachers and the time they have to be dislocated at a training centre.

In this work we will present a flow cytometer simulator, currently under

treated) parameters of cells (or by extension, of other biological particles) [1]. Some examples of parameters belonging to those categories are: a) the cell size (structural and intrinsic) b) the cell DNA content (structural and extrinsic) c) the cell chlorophyll (a fluorescent biomolecule) content (functional and intrinsic) and d) the intracellular calcium (functional and extrinsic). Current commercial flow cytometers can perform from five to ten simultaneous measurements.

A flow cytometer consists of one or more sources of light, a flow chamber, optical elements to focus light of different wavelenghts on to *n* detectors (currently 6), electronics to amplify and process the transduced signals and a computer [2]. With an acquisition software, the user is able through the computer to control all the instrument. In an operating flow cytometer, cells in suspension are made to flow in a laminar manner by a suitable hydrodynamic system (the flow chamber), such that they line up in single file moving through a beam of illuminating light, either a laser or an arc lamp. Once a cell has intersected the light beam, a process of light scattering and/or emission of fluorescence happens more or less intensively. The resulting light signals may be collected directly by a sensor (that is the case of the detector for forward scatter) or by lenses, selected dichroic mirrors and optical filters and focused onto photomultiplier detectors (that is the case of orthogonal scatter and of fluorescences). The light signals, amplified and converted into electronic pulses by the specified photosensors, are then measured and undergo an analogue to digital conversion. The digital signals are processed by multichannel analysers to provide frequency distributions for each measured parameter and displayed, in real time, on the computer screen, under the form of histograms (mono or multiparametric). After the acquisition, the data can be processed and analysed immediately or stored (list mode or histograms files) for later off-line analysis, by specific software. Whether measuring a single or multiple parameters, it is important to select appropriately the sample processment protocol, the optical configurations, the data acquisition and processment protocols and the proper archiving of the data files. Figure 1 depicts the major components a flow cytometer.

14.3. THE SIMULATOR

The training on the flow cytometer simulator is not intended to replace the traditional training, it is meant to enhance its efficiency and efficacy.

The first prototype is being designed to be used not only by beginners but also by more proficient students as well as teachers. Its purpose is twofold:

1- to provide students with a cost effective interactive tool which they can use as often as they wish, increasing their knowledge and experience without the need to occupy the real equipment and the teacher

2- to provide teachers with the possibility of preparing simulations which can be used in direct training sessions or included in hypermedia courseware.

Such a simulator should be an application that might be perceived by the user as a virtual cytometer, based on an adequate graphical environment and having associated models of the fundamental parts of this type of equipment, allowing the user to act on those parts and obtain the corresponding results. Although there are several different types of cytometers available on the market, all of them are based on the same physical principles. Thus developing a general simulator which could be tailored to each specific case, does not seem too difficult.

The choice of platform on which to implement such an application was much facilitated by the fact that all flow cytometers have a personal computer as fundamental component, in most cases a Windows platform.

In this section we will describe the main functionality offered to the user and some of the more relevant aspects of the user interface.

14.3.1. *User interface*

The flow cytometer itself seemed a logical choice for the metaphor of the simulator user interface. Thus the graphical environment

reproduces the essential characteristics of a flow cytometer.

Several dialogue styles were used (direct manipulation, menus and function keys) integrated as smoothly as possible, in order to accommodate several types of users (from beginners to experts).

To make the simulator as easy to learn and to use as possible by all the prospective users, two main modes were developed:

• a guided, less flexible, mode for beginners, which presents to the user a sequential dialogue (offering both semantic and syntactic assistance), adequate for inexperienced users of this specific application as well as naive flow cytometer users (i.e. typically students in their first attempts to use the simulator)

• a less structured, more flexible, mode for experienced users which have semantic knowledge, as teachers and advanced students.

The main functionality offered to the user (the same in both modes) is:

• acquisition - corresponding to virtually acquire data concerning a cell population contained in a sample

• parameter setting (protocol definition) - allowing the selection of parameters to be used for data acquisition and visualization

• visualisation - allowing the visualisation of the scatter plots (histograms) corresponding to the cell measures previously selected

• tools- allowing the use of several tools (as an oscilloscope and a bank of optical filters)

• archive- management of the sample archive

• help

All this functionality is available through a menu bar, function keys or direct manipulation.

14.3.2. *Possible relevant simulations*

A real flow cytometer has several fundamental internal parts and functions which can be simulated. Some of the corresponding variables are:

• the gain and voltage of the photomultipliers (signal acquisition)

• monitoring of the acquired signals (oscilloscope)

• the ADC conversion

• the role of mirrors and optical filters in the path of the laser beam

• setting compensation between two or more related signals

• quality control components, including negative and positive controls

• creating "what if" simulations adding equations to signals collected

The effect of different values for these variables is simulated and visualized on the resulting scatter plots, as well as on the pulse shape that can be viewed on a virtual oscilloscope.

14.4. EVALUATION

Evaluating the interest of this simulator, as is the case of other simulators [3], involves assessing if and how much the training in flow cytometry is improved by the use of this tool. This evaluation will have to be performed in laboratories involved in training, like those participating in the STEP - Specialty Training & Education Program of ISAC - The International Society of Analytical Cytology.

14.5. TESTING AND CERTIFICATION

Users can be formally tested as to their knowledge of how to interpret a specific signal or series of signals. For example, a user might need to be able to identify abnormalities in either instrument function, reagent quality or biological variations in a sample. Using a virtual cytometer all of these

simulations can be designed. This provides an excellent opportunity to create a variety of testing situations, each of which teaches a different component. It would be possible to use such a system as a partial certification step for medical technologists, students or instrument operators.

14.6. CONCLUSIONS

In this work we have shown the interest of flow cytometry simulators in direct or distance training and have presented a prototype of a flow cytometer simulator that is under development.

Currently, and to the best of our knowledge, there are no other simulators for this type of equipment, the existing training applications are unsophisticated, allowing only some simple animations of specific aspects of the flow cytometer. Our goal is to develop an actual simulator that could be called a virtual flow cytometer, offering a graphical environment that imitates a cytometer and conveys to the user the feeling he/she is using the actual cytometer. Having just the simulator can already be a great help to train people, however its usefulness can be enhanced if the resulting simulations can be used in hypermedia courseware or through the Internet.

The performance of the simulator, in making easier the training of future flow cytometry users, it is not yet assessed. This evaluation will have to be performed in institutions regularly involved in training.

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Internet Resources

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http://nucleus.immunol.washington.edu/ISAC.html

Homepage of Purdue University Cytometry Laboratories
http://www.cyto.purdue.edu

Homepage of the Iberian Society of Cytometry
http://www10.uniovi.es/sic/sic.htm

15. VIRTUAL REALITY IN SCIENCE EDUCATION: THE *VIRTUAL WATER* PROJECT

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Abstract **- Virtual reality adds a new dimension - immersion - to graphics display. Moreover, the characteristics of this new technology allow for a greater interactivity with the user.**

The *Virtual Water* project is the first work in virtual reality applied to the learning and teaching of Physics and Chemistry done at the Physics Department of the University of Coimbra. The project involves aspects as atomic and molecular orbits, electronic densities, bonds, molecular dynamics, phase transitions, etc.

It is a multidisciplinary work involving areas as computational simulation of physical and chemical systems, computer graphics and science education.

15.1. INTRODUCTION

The recourse to graphics, in particular to three-dimensional ones, for visualizing and interpreting information has been increasing in the research and teaching of sciences. In particular, that recourse is needed in domains where the interpretation of complex information is more demanding, as it happens in molecular modelation. Indeed, there are a lot of chemistry software packages, the most recent including the use of VRML [1,2]. The reasons for such interest are clear: in scientific research it is easier to obtain understanding from a three-dimensional model than from the simple reading of numbers or formulas; in the apprenticeship domain the utility of graphical methods, in particular the immersive ones, is being proved, for instance for forming correct conceptual models [3].

The *Virtual Water* project aims at the conception of an educational environment, joining molecular modelation with immersive three-dimensional graphic representation. The choice of water is justified by the fact that this is a common and relatively simple substance. Its study has interested many investigators who do realistic simulations of water in Physics, Chemistry and Biology [4,5]. However, less attention has been given to the pedagogical exploration of water simulations.

The subjects approached in the project go from the study of the molecule geometry to the structures of the solid, liquid and gaseous phases, through the study of the electronic density and the chemical bonding by hydrogen bridges. Since some studies of water start with atomic orbits, in particular with the hydrogen s, p and d, this subject is also included in the project.

15.2. GENERAL FEATURES OF THE PROJECT

The exploration of the contents is done in two ways (Figure 1):
- Macro   Micro - from the water phases to the atoms (full line in the Figure);
- Micro   Macro – from the atomic orbits to the water phases (dashed line).
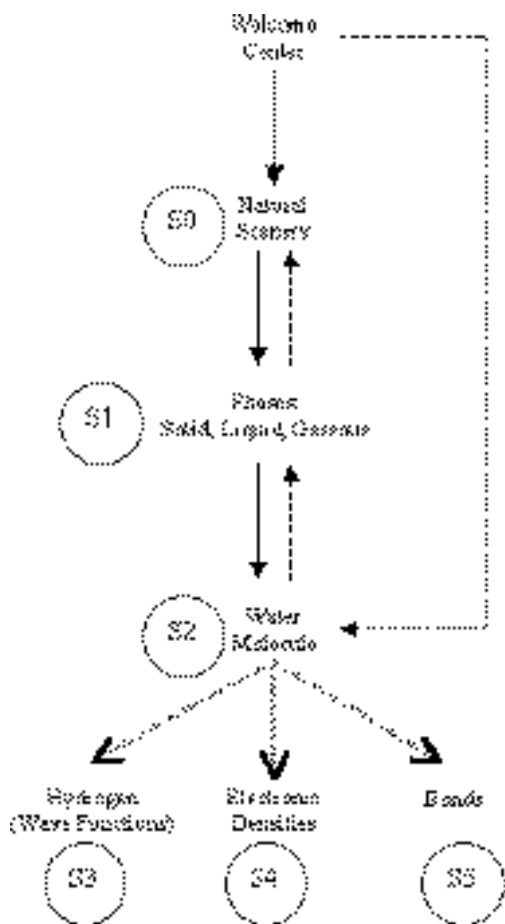
Figure 1- Scheme of the environment *Virtual Water*. The dashed line denotes the content exploration going from the macroscopic to the microscopic side while the full line denotes the exploration going from the microscopic to the macroscopic side.

In any case, the scenery exploration is preceded by navigation in a training environment. The goal is to help the user to achieve good adaptation to the interfaces (glove and Head Mounted Display), navigation and interaction in virtual worlds.

Our project comprises two phases: in the first (which is under way) the visualization of the water molecule geometry (S2), the hydrogen bonds (S5), the water electronic density (S4) and hydrogen wave functions (S3) are done. In a second phase, other aspects will be introduced allowing for the study of phase transitions (S1).

For implementing the virtual environment we use two software packages running in parallel in two PC's. One of the packages, *WorldToolkit*, serves the definition and creation of the virtual scenarios while the other, *Gaussian 94*, does the calculations related with the water molecule namely, geometry optimization (S2) and the electronic density (S4).

We use the following hardware: two PC's with Pentium Pro at 233 MHz, with 64 Mb of RAM, in network, with one of them (that which does the virtual environment rendering) using an accelerator graphic board *Matrox Millennium II AGP* with 8 Mb of RAM. For the navigation and immersion in the virtual environment, we use the Head Mounted Display V6 from *Virtual Research*, as well as one *Cyberglove* from *Virtual Technologies* and a position sensor to two receptors, *Isotrack II*, from *Polhemus*.

The final product of this work will be disposed to the school community through the Competence Center "Nónio-Softciências".

15.3. CONCLUSION

The use of graphics is, indeed, a powerful tool for visualizating and understanding of complex and/or abstract information. The immersion capacity is a recent aspect to be

explored and evaluated. A virtual environment for the teaching of Physics and Chemistry is being developed to test the possibility of applying virtual reality in teaching and learning. The work is in a preliminary phase of execution, so that its evaluation cannot yet be done.

15.4. ACKNOWLEDGEMENTS

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C. Multimedia/Hypermedia Development tools

Invited Paper:

Christoph Hornung, "*PLATINUM: A Framework for I*Net-based Simulation and Training*"

Communications:

E. Carrapatoso, R. S. Moreira, J. M. Oliveira, N. G. Ribeiro, "*A virtual digital library*"

J. Paul Robinson, G. L. Coppoc, "*WEB-on-a-disc: an innovative use of the WEB on CD ROM. Application in Science Education*"

J. P. Robinson, M. Overley, "*BIOSCOPE: an NFS funded project to develop interactive biology CDs Linking students and scientists via the WEB*"

Sampedro, R. Rubio, A. Pavon, D. Suarez, A. S. Gimeno, Y. del Cura, A. M. Nistral, "*WELLPATH: Welcoming Environment for Lifelong Learning in PATHology*"

Magnus Helander, "*Breaking the hyperlink, scenario-based approach to learning*"

R. Rubio, C. Oliveira, C. Secades, F. Lima, F. Sansonetty, A. M. Nistral, A. Sampedro, "*Internet Training/Learning Management System*"

A. Reggiori, C. Best, P. Loekkemyhr, D.W. van Gulik, "*A Telematics Learning Environment on the European Parliament: the ParlEuNet System*"

The invited paper by C. Hornung, "*PLATINUM: A Framework for I*Net-based Simulation and Training*", describes the work being developed by his group at Fraunhofer Institute of Computer Graphics which is based on their Modular Training System (MTS), which integrates course presentation, production and administration. The system architecture supports the reuse of courseware modules and favours the close cooperation of the technology providers and the end users through rapid prototyping of small learning modules.

Seven communications on the theme are included. Magnus Helander, "*Breaking the hyperlink, scenario-based approach to learning*" and E. Carrapatoso et al*, "A virtual digital library*" describe some very innovative approaches in quite distinct fields of application. In their developments both make use of object-oriented technologies. Helander uses the technology for the dynamic, i.e. with the learners' contribution, construction of narratives. Carrapatoso et al. describe the fuctionalities of a Virtual Digital Library as an environment supporting the production, search and retrieving of multimedia documents provided by a client-server system architecture that makes ample use of standardised system tools. J. Paul Robinson et al., describe the work being done by his group at the University of Purdue (USA) on biology education in "*WEB-on-a-disc: an innovative use of the WEB on CD ROM. Application in Science Education*" and "*BIOSCOPE: an NFS funded project to develop interactive biology CDs. Linking students and scientists via the WEB*". A. Sampedro et al., report on work on developing tools for the continuing education of medical doctors being carried out at Universidad Oviedo (Spain), in "*WELLPATH: Welcoming Environment for Lifelong Learning in PATHology*". R. Rubio et al., describe an "*Internet Training/Learning Management System*" and A. Reggiori et al., the development of a multimedia educational platform for

secondary schools in "*A Telematics Learning Environment on the European Parliament: the ParlEuNet System*".

16. PLATINUM
A Framework For I*net-based Learning and Training
INVITED PAPER

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*Abstract-***This paper presents *PLATINUM*[3], a worldwide network for innovative learning and advanced training. PLATINUM is based on the Internet-based Modular Training System, MTS; which anticipates tomorrow's learning scenarios by providing flexible, on-demand, user-adaptive, co-operative, telematics-based, distance learning services. Based on MTS, innovative application scenarios in diverse areas such as formal education, continuing eductation and training on demand are under development. PLATINUM will show the potential of efficient and effective co-authoring of courseware and flexible, personalized and cost-effective learning for users. The vision of PLATINUM is to foster the collaboration of multiple authoring teams in the development of global courseware domains.**

16.1. INTRODUCTION

Traditional training focuses on teaching in either classroom-like settings at fixed times and places, or in individual learning settings which lack teacher guidance, feedback, and the opportunity to apply the presented information. The upcoming information age demands new training concepts and infrastructures for life-long, high quality training. The learners need to be able to access on-demand and goal-oriented training from their workplace or at home. Training should also be adapted to the individual knowledge and learning style of the user. Even within a high quality learning environment, the human factor will remain vital to allow expert consultation, teacher guidance, and user co-operation.

These environments introduce additional requirements. Training providers need applications by teams of experts, pedagogues and media designers for efficient multimedia courseware production. The accumulation of knowledge in such environments demands efficient management concepts to enable the multiple use of existing courseware.

Computer-based distance learning satisfies this need by providing flexibility with respect to place and time. Today we can identify steps towards integrated solutions based on the Internet and Intranets (*I*net*) which enables access to the learning material independent of the learner's time and place. In contrast to stand-alone learning, distance learning led to a trend to merge the whole world of education into one global network where the learners could study virtually and access innovative multimedia courseware combined with (adapted) traditional learning approaches.

The paradigm shift towards I*net-based learning and training requires the close cooperation of both technology providers and end users. The project *PLATINUM* (*P*resentation, *L*earning and *A*dvanced *T*raining in the *I*Net *U*sing the *M*TS) combines the forces of the *INI-GraphicsNet* (The International Network of Institutions for advanced education, training and R&D in computer graphics technology, systems and applications) to develop an innovative Java-

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[3] PLATINUM stands for *P*resentation, *L*earning and *A*dvanced *T*raining in the *I*Net *U*sing the *M*TS

based learning and training platform (the MTS system) and to demonstrate the potential of I*net based learning and training in heterogeneous application areas such as formal education, continuing education and training on demand.

Only PLATINUM's incremental approach, based on rapid and small prototypes with
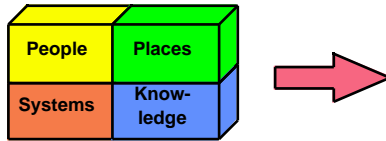
Nowadays, learning and training systems provide local solutions and are realized as black boxes incorporating all these components. In the Web-based future scenario, all components will be distributed via global networks (*Fig. 1*).

16.2.2. *Roles involved:* People
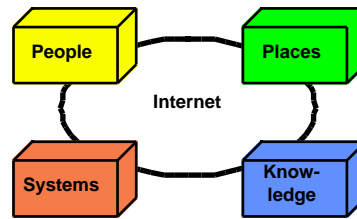
Figure. 1: Trends in Internet-based Learning and Training

short innovation cycles based on the end users' feedback will lead to the results we aim at: the successful usage of I*net technologies for effective learning, training and qualification applications.

This paper presents PLATINUM as a framework for technological development as well as an environment for field trials and application experiments. In chapter 2, the underlying concepts of I*net-based learning and training are outlined. In chapter 3, courseware concepts are sketched. Chapter 4 presents the MTS-technology. In chapter 5, the synergy of these pieces in PLATINUM are described with a special emphasis on simulation-based training.

16.2. CONCEPTS OF INTERNET-BASED LEARNING AND TRAINING

16.2.1. *Introduction*

Learning and training can be characterized by four parameters: the *people* executing the learning and training tasks, the *places* where those people act, the *systems* providing the technical infrastructure, and the *knowledgeware* as the underlying courseware material.

Traditional computer based training (like CD-ROM based CBTs) consists of two strictly separated phases: courseware production and courseware delivery. The underlying paradigms are based on the assumption of single authors and single learners not interacting with each other (*Fig. 2*).
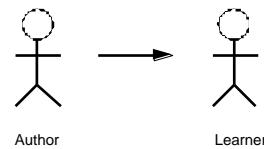
Figure. 2: Human Networking in Traditional Computer-based Learning and Training

This situation changes completely in I*net-based learning and training scenarios. Here, worldwide distributed collaborating *communities* are considered instead of single actors. Cooperative authoring and group learning are obvious usage scenarios in network environments. Moreover, learners can give direct feedback to the authors, which, in return, is leading to shorter courseware innovation cycles.

Besides this, new roles arise which are specific for I*net-based learning and training: online tutoring, information brokering, and knowledge tailoring (*Fig. 3*).
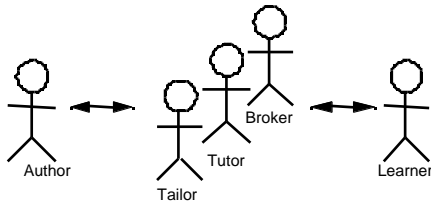
Figure. 3: Human Networking in
I*net-based Learning and Training

Online consulting describes the concurrent usage of courseware by a teacher and a student, to which both may have different views and access rights to the underlying course. The real advantage of online consulting as compared to traditional educational approaches is the network-presence of tutors: the Internet allows users to find the best-suited tutor worldwide for a specific question.

Internet-based learning and training is based on worldwide distributed knowledge domains (see below). As the available amount of information explodes, the configuration of appropriate individual courseware becomes more and more important. The *knowledge tailor* fills this gap. He serves as a mediator between producers and customers by transforming raw material into high-quality knowledge products.

The *information broker* mediates between supply and demand of knowledge products. As in the brokering of real goods, appropriate brokering becomes important in large-scale markets.

In summary, I*net-based learning and training changes the way we interact with knowledge in two main ways: unidirectional static chains are being replaced by highly interactive networks and many different *knowledge mediators* are arising.

16.2.3. *Learning Environments:* Places

Traditional learning and training takes place at fixed locations and at predefined times. In stand-alone learning scenarios, the learner works isolated and, in general, using entry-level environments. The available material is restricted, and there is no possibility for

tutoring or reflection about the lessons learned.

Electronic classrooms overcome these problems by providing access to multimedia courseware, yet still supporting the learning in groups and the direct interaction with the teacher. Moreover, advanced infrastructures such as collaborative virtual environments allow for new approaches to computer-based education and training.

I*net-based learning and training environments go even one step further. Here the notion of *place* makes no sense and is replaced by *ubiquitous computing*, i.e. worldwide transparent access to courseware domains independent of their physical location. Moreover, since in the Internet application logic and access via user interfaces are separated by default, individualized access becomes more prevalent.

16.2.4. *Worldwide distributed* Knowledge Domains

The creation and usage of Internet-based knowledge differs completely from traditional courseware with respect to the following aspects:

Use of references instead of copies
Availability of multi-author domains
Separation of structure and content
Provision of data and metadata
Support of dynamic and active courseware

Internet-based courseware is used *on demand*; it is no longer prefabricated and then delivered. Moreover, a community of users accesses the same courseware material. On the one hand, this facilitates the reflection about the learned knowledge. On the other hand, additional methods for individualizing the common course (e.g., by personal annotations) have to be provided. Moreover, the user has to pay for *usage* instead of *ownership* of courseware.

The Internet provides new means of collaboration. Large courseware domains cannot be provided by single individuals anymore but instead need to be created by teams of authors. Therefore, appropriate

mechanisms for collaborative work on courseware domains have to be provided.

The reuse and adaptation of information stored in knowledge domains requires strict *modularization*. Courseware structures incorporating, for example, didactical principles have to be strictly separated from the content used. This separation allows the reuse of already proven material in different contexts or learning scenarios.

Courseware material is always used in certain learning contexts. Therefore, *metadata* describing the semantics of the data in the courseware domain have to be provided. Since a single material can have diverse meanings in different contexts, varying metadata may exist to a single data entry.

The fact that courseware is referenced instead of copied decouples the lifecycle of the courseware and the lifecycle of usage. This enables the usage of *actual information*. Only I*net-based courseware can incorporate actual and dynamically changing information.

16.3. I*NET-BASED LEARNING AND TRAINING SYSTEMS

16.3.1. *Introduction*

Traditional courseware systems are based on proprietary authoring environments producing executable course blocks.

Internet-based learning and training systems, however, can be seen from two perspectives: the extension of traditional local authoring systems to the WWW or the availability of learning and training as an application on top of generic Internet-based architectures.

The first approach is pursued by systems like Macromedia [Macromedia 1998] or Toolbook [Asymetrix 1998]. In the first stage, HTML-export was made available to support the delivery via Web-Browsers. Next, server-side administration tools were provided. However, these approaches require proprietary solutions.

The provision of generic learning and training platforms has been undertaken, for example, by the Deutsche Telekom in the Global Learning system [GlobalLearning 1998], Oracle's OLA [Oracle 1996], Lucent's [Lucent 1998] or Macromedia's Attain Enterprise Learning System [Macromedia 1998]. Lotus Learning Space [] focuses on the support of processes in learning and training based on Lotus' Notes and Domino technology. These architectures focus on the provision of distributed servers providing generic support for user and courseware management. However, the courseware modules still remain proprietary.

The MTS-system combines the strengths of both approaches. Designed on top of a three-tier Web-architecture, it provides both kinds of distributed courseware servers, an innovative courseware concept, as well as support for traditional courseware.

16.3.2. *Architecture of the MTS*

The MTS System is based on a state-of-the-art, three-tier WWW architecture, encompassing a client layer, an application server layer, and a remote resource layer (Fig. 4).

The *Client Layer* contains the WWW browser and the MTS client. It defines the top level of a virtual learning environment and offers graphical user interfaces to the learner. While the WWW browser is used for the presentation and interaction of the course material, the MTS client is implemented as a Java-based extension (plug-in). The MTS client supports functionality such as graphical authoring and interactive group management. As an add-on to the WWW client, the MTS client is implemented with Java to complete the learning environment, e.g., to start the video-conferencing software to support the online tutoring.
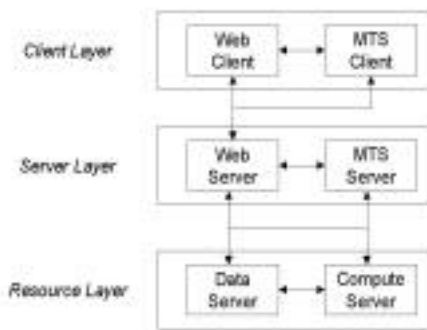
Figure. 4: Architecture of the MTS System

The *Application Layer* contains the WWW server and the MTS server (CBT server). While the WWW server provides the standard components for the network connection between client and server side, the MTS server contains the application logic to steer learning and training sessions. This mainly encompasses the course control, but also includes components for session management and group work.

The *Resource Layer* consists of database and compute servers. A database server contains material and user data, and a compute server executes applications (simulations and microworlds) to effectively support training applications. Both the database as well as the compute servers can be distributed themselves.

16.3.3. *The MTS Server*

16.3.3.1. *Overview*

The MTS server is a CBT server, which communicates on the one hand with the WWW server to exchange the WWW-based information and, on the other hand, with the database server to get and store the course material and user data. The user sends requests through the WWW browser to the WWW server using the HTTP protocol. The WWW server redirects this request to the MTS server via a CGI program. The MTS server preserves the different information

from permanent user data to user interaction, from course contents to individual course flow, and exchanges this information with the MTS database.

Every request from a client can be identified through the 'cookies' mechanism. The behavior of learners will be stored in the user profile. During the operation of a client request the user profile is used to determine the course flow individually for every user. The fixed 'links' of normal WWW documents are replaced by the flexible course structure, considering the interactions made by users, as well as the users' knowledge states.

The compute server is connected by CGI calls, if a course unit contains such requests. The results from a compute server, such as graphical images or video stream, are sent back to the WWW server and presented in the course online. The other possibility for connecting the compute server is the IIOP (Internet Inter-ORB Protocol) architecture. *Fig. 5* shows an exploration unit that calls a ray-tracing teleservice with different parameters to get the illumination effects online.
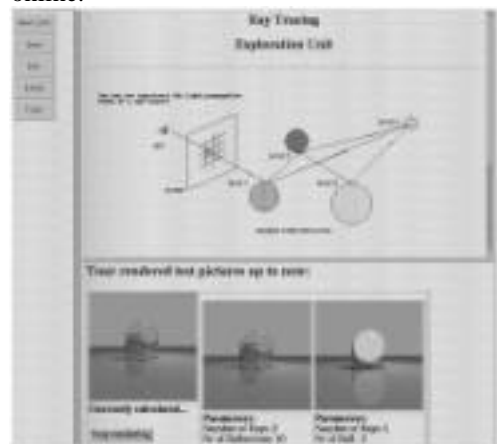
Figure. 5: Exploration Unit Using a Remote Compute Server

16.3.3.2. *Login and Session Creation*

The user of the MTS system always starts with a login message. This message identifies the user and its role: administrator, author or learner. The session management

handler checks the input with user data stored in the user database. Dependent on the role, the executive then creates a new instance of the course runtime handler or the course-authoring handler. Next, a session ID is created which uniquely identifies this session. The executive uses this ID for passing further requests. The session ID is passed back to the WWW client using the 'cookies' mechanism. This returns a unique identification of the WWW client to the MTS server. The according handlers then process all subsequent requests.

16.3.3.3. Course Authoring

In authoring mode, the authors first select a course, then the authoring environment is started and the authoring client, implemented in Java, is downloaded. This tool supports the interactive graphical design of course nodes and units, while standard editors are used to produce course material. In authoring mode, both virtual and direct references can be created. The authoring clients send messages describing the creation, modification and deletion of nodes and units. These messages are passed via the executive to the course-authoring handler. The authoring handler then uses the mapper for mapping virtual references onto direct references and calls the component management services for accessing the database.

The author can preview the course using the course runtime handler.

16.3.3.4. Course Runtime Handler

The course runtime handler is used either in learner mode or in authoring preview mode. The user starts the course runtime handler when selecting a course node. This node is loaded and the course runtime handler executes it by interpreting the CDL script.

The course runtime handler distinguishes between virtual and direct references, and between references to nodes and references to units. All virtual references are passed over to the mapper service, which returns a set of direct references. Next, direct references to units are passed to the converter which, by means of the component management service, returns an HTML page.

Direct references to nodes are accessed directly via the component management service. This node is then interpreted directly in a recursive manner.

The actual course component (node or unit) may return a value via a Java applet. This value is passed via the executive to the course runtime handler, which updates the user profile and, based on the actual value of the user profile, determines the next course component to execute.

16.3.3.5. Group Management

The group management functionality is available after a user is logged in, yet it is independent from the actual session management. A user can watch active user groups, join user groups, and communicate with other users, such as via email. Moreover, synchronous communication and tele-tutoring are supported.

16.3.4. Personalities

The MTS integrates course presentation, course production, and administration into a single system using three different operation modes: the course runtime handler mode, the course authoring mode, and the administration mode. These operation modes are used by the different kinds of users, such as learner, author and administrator, to support the different kinds of MTS usage. "Authors" will typically be teams of specialists (educators, scientists, programmers, and media designers) which all have their dedicated tasks. In the course runtime handler mode and the course authoring mode the users use the remote client to connect to the LTC, while in the administration mode the LTC administrator uses the administration tool locally to manage the course configuration and the user data stored in the MTS database. For the different kinds of usage, the MTS offers the responsible modules and tools, both at the client site and the LTC site, which are integrated smoothly to a complete MTS system.

16.3.5. *Learning and Training Centers*

The integration of various learning aspects is the goal of the Modular Training System (MTS). From the users' point of view, the MTS is like a virtual classroom or virtual training center which offers a complete multimedia distance learning environment including course presentation, course production, user and course administration, group learning, and online tutoring (*Fig. 6*).

Learning and training takes place in MTS according to the following model. First, two main types of sites should be distinguished: the Learning and Training Center (LTC) and the user's workplace.

Learning and Training Centers are composed of a standard WWW server, a MTS server, and a MTS database server, and provide management functionality for distributed courseware and administration functionality for users. The LTC is the central infrastructure element since it is the access point to all training facilities. Each LTC offers its training facilities to registered users. It administrates access rights to courseware, assigns experts for consultation, and aids the formation of virtual learning groups. The LTC is responsible for guaranteeing the quality of new courseware made available to the entire Virtual LTCs by their local authors, and it is the owner of a distinct subset of the distributed courseware domain.

On the client site, the main components of the MTS are the WWW browser and its add-ons. The client runs a course front-end at the trainee's and author's workplaces. It handles the user's input and edits, downloads, and displays the course framework and the different kinds of courseware material.
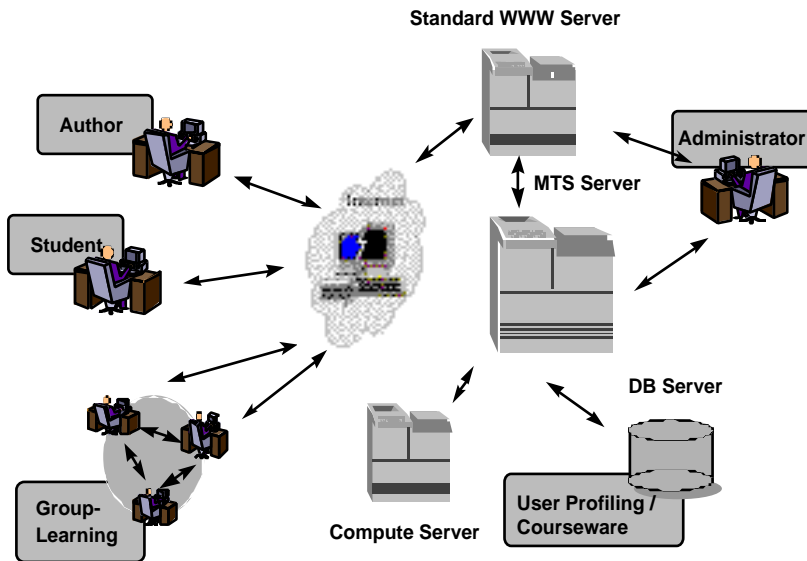
Figure. 6: Learning and Training Environments

Since the material is stored in the Learning and Training Center, each LTC must run a WWW server to connect the WWW client. The MTS server provides all the necessary

these components from their description using metadata.
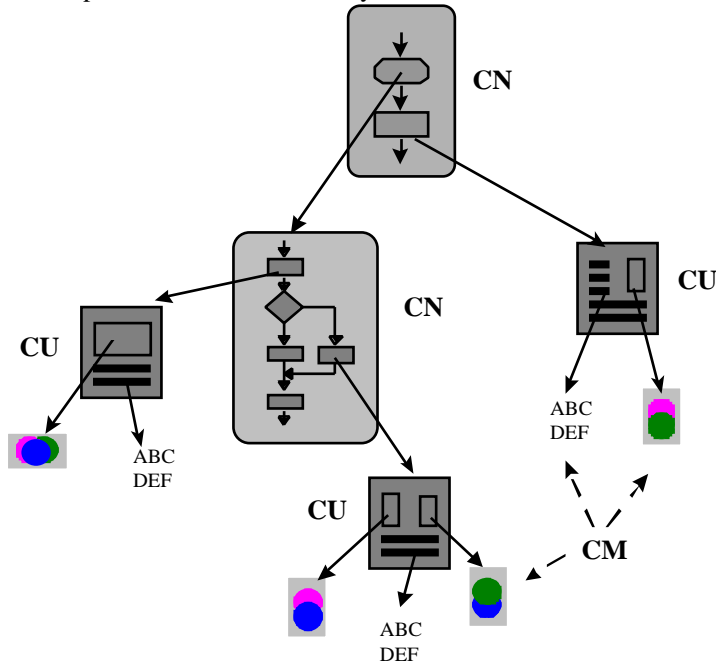
Figure. 7: Modular Structure of Courseware

functionality to control the course, and the database provides the multimedia courseware and user information.

LTCs are interconnected via terrestrial and satellite links to form a global Virtual LTC that provides transparent access to all courseware for users from arbitrary locations with different networking bandwidth and client configurations.

16.4. COURSEWARE CONCEPTS

16.4.1. *Introduction*

MTS strictly applies the paradigms of modularity and reusability to courseware. This leads to two design concepts: a modularity concept composing courses out of different, clearly separated components, and the strict separation of the content of

16.4.2. *Structuring Courseware*

Courseware is broken down into three different categories: course nodes, course units, and course material. These categories form a hierarchy of abstraction and support the design of modular and flexible courseware (*Fig. 7*):

Course Nodes define learning goals. A course node does not contain any information about *how* this learning goal can be reached. Courses are arranged as networks. Each course unit delivers a return value indicating the learner's success. Dependent on this value, the appropriate "next" course node can be chosen. Herewith, a complete course can be described on an abstract level. The content of a course node is a script in the special language CDL (course definition language). This script
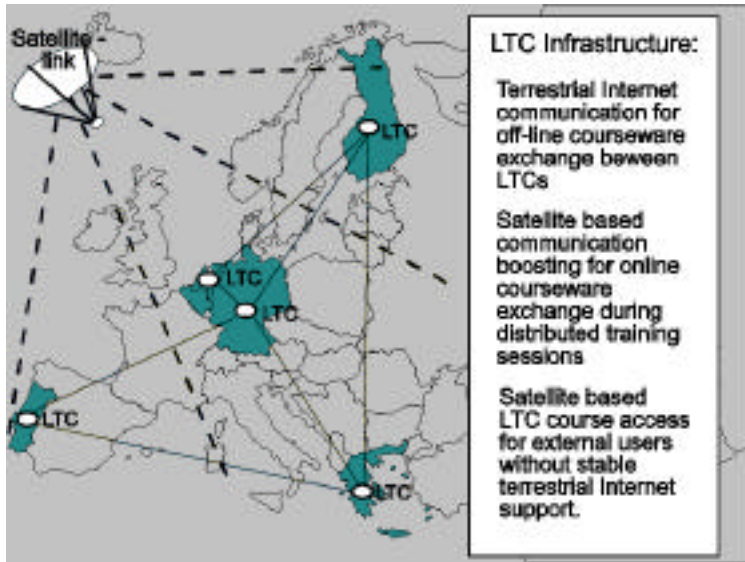
Figure. 8: The IDEALS Network

describes the implementation of the course node and may reference either other nodes or units. It never references material herewith supporting the clear separation of structure and content.

Course Units are implementations of specific steps in the learning and training process. Course units may either be presentation units, exploration units or test units. Each of these unit types can be implemented using characteristic templates. Course units are self-contained. They contain only references to course material, but neither reference other units nor nodes. In this sense, course units form containers of course material. They are implemented as an extension of HTML, the so-called HTML-M (for MTS-HTML). This extension includes special tags for referencing (see 4.2). Course Units deliver a return value indicating the learner's success when traversing this unit.

Course Material describes the material used in the course units and, herewith, the visible parts of a course. The course material consists of Internet standard formats like Text, Audio, and Video.

In order to enable reuse and multiple use of courseware on a large-scale, each module is stored as a separate entity, is self-contained and implements a common

interface. This also allows course adaptation to the individual needs of the trainee by using the best fitting modules.

The flexible linking between the course documents requests the separation of the course framework and the course contents. The MTS server controls the structure of the course, independent of the WWW documents, which represent the course content. This allows the reuse of the course material in different courses. For a special user group, the course can be produced with a special course framework, yet can reuse the course material available. In this context, the database server plays an important role: In order to use the existing course contents the domain must be efficiently browsed to retrieve the suitable material. For this domain browsing, the self-description of material and catalogues must be stored in the MTS distributed multimedia database.

16.4.3. *Referencing of Courseware*

An orthogonal concept of the MTS courseware is the *referencing* of courseware. The different courseware components introduced in section 4.1 are never embedded directly, but are always referenced instead. Moreover, to every courseware component

there exists a separate *description* containing metadata of this component in the form of characteristic attributes. Even more, constraints on the attribute—value pairs—can be defined. Herewith, the following hierarchy of references exists in the MTS system:

- direct references, pointing to a course component's data and metadata directly
- virtual references, describing a constraint set of direct references

While a direct reference points to single component, a virtual reference defines an open set of characteristics and, therefore, of course components.

This design principle allows the concept of *late binding* to be introduced in courseware. While a direct reference is bound at authoring time, virtual references are late bound. They either can be bound at a special configuration step before course delivery, or they can be bound at runtime. The binding at runtime allows users to choose the best-fit course component depending on their learning progress.

16.5. PLATINUM

16.5.1. *Introduction*

The INI-GraphicsNet has several years of experience in the area of I*net-based learning and training in large-scale projects in Germany (COBRA-3) and on a European scale (IDEALS).

In the COBRA-3 project [Borgmeier et al. 1996] sponsored by the Deutsche Telekom, the MTS-system has been used as basis for the development of advanced courseware by Fraunhofer institutes to teach employees in small and medium-sized enterprises. Courseware in such different areas as logistics, development of ASICs, and introduction into CAD systems has been developed and taught in Germany via ISDN-networks.

In the IDEALS project [Borgmeier & Beyer 1996] sponsored by the EU Telematics Application Program, a European-wide network of LTCs has been installed demonstrating different usage scenarios in small and medium-sized enterprises as well as in institutes of higher education (*Fig. 8*). The university pilot is the basis for the Computer Graphics courseware domain[4] [IDEALS 1997].

Based on the experiences gathered in these projects, the PLATINUM network is currently set up. It connects the different branches of the INI-GraphicsNet and, herewith, defines a worldwide network of excellence in learning and training in all areas of computer graphics (*Fig. 9*). The different branches are connected via high-performance networks (ATM, satellites) and provide state of the art learning facilities such as collaborative virtual environments.

PLATINUM forms a global learning and training network and will serve as a common platform for the development of different kinds of demonstrators in areas like training on demand, collaborative simulation of complex technical systems, teaching and tutoring at universities, or qualification for workers in industry.

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[4] The available courses can be executed on the TUD LTC at URL http://ltc.gris.informatik.tu-darmstadt.de/.

univers·ity·year·98
new technologies for higher
education

Figure. 9: The PLATINUM Network

16.5.2. *The PLATINUM Network*

PLATINUM is based on an innovative network infrastructure. All branches of the INI-GraphicsNet are connected via the Internet for data exchange as well as via ISDN connections for audio and video conferencing. Here, the usage of MCU (multi conferencing units) supports the online collaboration of teams at up to four places. Additionally, innovative application scenarios can be demonstrated between Darmstadt and Providence using ATM and between Darmstadt and Coimbra using Satellite connections.

16.5.3. *The PLATINUM Application Areas*

PLATINUM will supports different application areas: formal education, continuing education, and training on demand.

The application area *formal education* develops innovative usage scenarios especially in universities and institutes of higher education (IHEs). Based on the results of IDEALS, the main emphasis is in the development of a common courseware basis (knowledge domain) for computer graphics. Universities in Darmstadt, Coimbra (Portugal) and Oulu (Finland) will continue to extend this domain. Besides the creation of courseware material, a uniform catalog for the description of this material will be developed, which eases the reuse of courseware by other authors.

The application area *continuing education* aims at the development of knowledgeware for general usage and for the qualification of employees. One example of this area is the development of cross-media delivery of educational Material, as described later.

The application area *training on demand* aims at the support of information access at the working place, online consulting and simulation-based high-tech training. Across the different branches, experts will collaborate in both the creation and usage of trainings.

These different application scenarios cover the whole spectrum of I*net-based learning and training: PLATINUM will serve as a worldwide distributed network of excellence for all aspects of innovative learning and training.

16.5.4. *Simulation-based Training in Multimedia Systems Engineering*

Complex technical systems typically consist of heterogenes modules and subsystems like electronic, mechanic or hydraulic parts and therefore require the collaboration of experts from different engineering disciplines. The training of the behavior of such systems requires the support of different views as well as the support of different training processes specific for each trainee.

As an application example in the area of Multimedia Systems Engineering (*MUSE*), IGD develops a simulation-based training in for the rear axis steering system of a Daimler Benz Unimog [Deegener et. al. 1995]. In PLATINUM, the simulation of this system has been integrated into an innovative training scenario that demonstrates the following features of simulation-based training.

Simulation-based Training Architecture

In web-based training systems, the web server plays a central role: the training is page-oriented and is based on a request-response loop: the pages are sent to the user, the user acts locally with the content of the page and then requests the next page.

This paradigm is not well suited for continuing simulation and the support of multiple simultaneously interacting trainees. To support simulation-based training, the web-based MTS-System has been extended (*Fig. 10*).

In this architecture, the MTS-server only manages the creation or joining of the remote simulation objects while, during the simulation, a separate continuous connection between the client's view and the simulation is established. This leads to a new quality of simulation: the integration of web-based page-oriented courseware with embedded continuous connections to remote simulations.

Remote Java-based Simulation

A key property of simulation-based training in PLATINUM is the separation of the
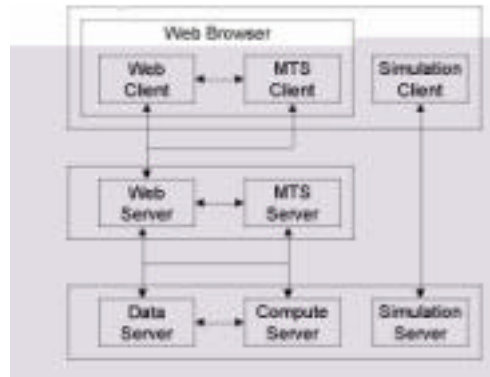
Figure. 10: Extension of the MTS Architecture for Continuous Simulation

simulation model and the client's view. The view and the model communicate via Java RMI or, in case of a non-Java model, via CORBA-IIOP. This concepts supports the usage of high-performance compute servers for simulation as well as the design of heterogeneous user interfaces (*Fig. 11*):
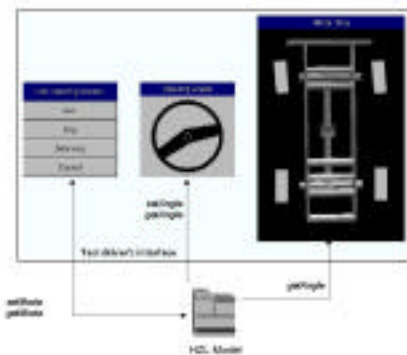
Figure. 11: Remote Java-based Simulation

Support of Different views

The separation of simulation model and simulation view supports easily the support of different views: depending on the actual training situation, the trainee can inspect the appropriate parameters of the simulation model. This increases the training effect substantially. The trainee can switch between different views while the simulation is running (*Fig. 12*).
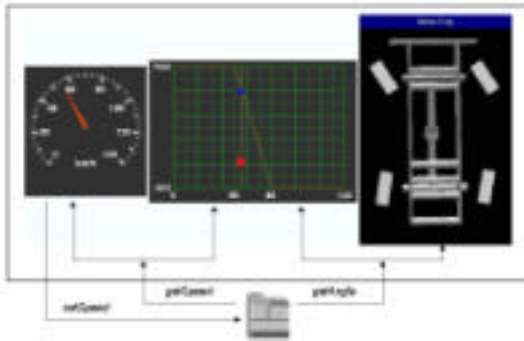
Figure. 12: Different Views

Support of multi-user scenarios

Another consequence of the separation of simulation model and client's view is the easy support of multi-user trainings.
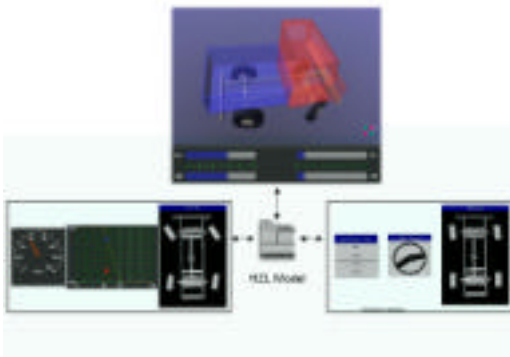
Fig. 13: Multi User Training

At the same time, different users can collaboratively inspect the system, each having its specific view. This supports the collaboration of virtual teams in group training and online consulting scenarios

16.5.5. Cross-media Delivery of Educational Material

Within the CAMPuS (Cross Application and Media Publishing Services) project, Fraunhofer CRCG targets the unification of two of its R&D areas—Cross-Media

Publishing (CMP) and Distance Education: While CMP is targeting the preservation of concepts throughout the distribution of information using diverse publication media, efficient distance education faces a rather different task. It has to reuse information entities for different educational purposes and audiences (applications), such as for entry-level education, advanced training on the job, or even high-level overview presentations. Obviously, each of these applications puts different demands on the underlying media, yet they can also be used for non-educational publication purposes. On the other hand, CMP needs to consider various publication purposes as well. Therefore, the exploitation and development of MTS as a platform that supports the integration of, and common R&D for both areas, provides a promising approach to support a variety of applications and customers. In this sense and supplementing the Computer Graphics courseware domain mentioned above [Klein & Encarnação 1997], Fraunhofer CRCG's distance education efforts additionally include cooperation with the Computer Graphics Lab at Brown University, the Computer Algebra group of the University of Rhode Island, the Rhode Island School of Design (RISD), and Bryant College. Furthermore, in cooperation with RISD and the Distributed Publishing Lab—an international collaboration of institutions from Germany, the US, Portugal, and South-East Asia focusing on CMP over high-speed global networks for business, scientific, and educational purposes—Fraunhofer CRCG has established a Lab for Cross Media Publishing in which the CAMPuS project is pursued.

16.6. FUTURE WORK

The actual MTS system is based on currently established Web-technologies. The server side is implemented mainly in C++, while the clients use Java and Javascript. A future version of the MTS system, currently under development, will be based entirely on Java

and will use advanced techniques, such as
RMI, JavaBeans, and EnterpriseJavaBeans.
Herewith, a better distributability and
scalability of the system will be reached.

Another focus of research will be the
development of a component architecture for
courseware. Especially in the area of
simulation-based training, this will ease the
design of tool boxes of pre-fabricated
elements to support course configuration
instead of the development of new courses.

The PLATINUM-network will serve as the
platform for the demonstration and
development of application scenarios based
on this new technologies.

16.7. CONCLUSIONS

Internet-based learning and training will not
replace the traditional approach to learning
abruptly, rather it will have to prove its
advantages over the traditional forms. It is
expected that it will become an indispensable
supplement for life-long high quality training
soon. The multimedia distance learning
system MTS concatenated the up-to-date
CBT features to the Internet to satisfy the
important pedagogical and didactic demands
with its concepts of multi- and reusability,
modularity, and adaptability. MTS is open
for new media types and running in a
heterogeneous computer environment. Its
modular, scaleable, open system architecture
is designed to support reuse of courseware
and to meet the challenges of global, life-
long learning for the future. The
PLATINUM network will serve as an
network of excellence in the areas of system
development, course creation, configuration
and adaptation as well as innovative
courseware usage scenarios with special
emphasis on the support of worldwide
distributed virtual teams.

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17. A VIRTUAL DIGITAL LIBRARY

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Abstract - **Digital libraries may play an important role in spreading cultural and education through the Internet and may act as the interface between the research community and the commercial and industrial worlds.**

In this paper we present our view of a Virtual Digital Library, an environment in which the users could meet and produce, search and retrieve multimedia documents. The specification of an object-oriented architecture of software components that could be used to construct the Virtual Digital Library is presented, as well as the development work currently underway that will conduct to the final service.

17.1. INTRODUCTION

The process of co-operation between groups of people and the ways they interact and exchange information are suffering an enormous transformation. This evolution has implications in the telematic process of interdependency and co-operation among fellow workers geographically scattered over different locations of the same enterprise or even between different enterprises. Digital libraries have an important role in this new way of organising and managing people's work and information flow.

When we think about digital libraries we should consider aspects, as different as the information storage and management, the ergonomy of interfaces, the browsing and querying methods, the support for distance learning and the protection of intellectual rights over information.

Digital Libraries are becoming more and more important in the visibility and dissemination of scientific work/research, distance learning and self-education, co-operative mechanisms and virtual interfaces[1]. We can foresee digital libraries as the nodes of knowledge in the future world-wide information society networks. They will be powerful and specialised information systems that will support information gathering and should act as knowledge diffusion centres. Digital libraries could be seen as multimedia telematic information systems particularly suitable to act as the interface between the academic world and the industry, based on an infrastructure for storing and delivering multimedia information (e.g. video conferencing, interactive video, multimedia documents, multimedia chat rooms, specialised discussion forum).

The digital libraries have emerged as innovative information systems regarded as repositories of knowledge embedded with useful functionalities for co-operation between users. They represent the new systems that combine new types of resources through the complex association of various media types. The technological evolutions among storage and representation of different media and the flexibility introduced by the standardisation of cataloguing and classification rules were introduced in the digital libraries architectures. Nowadays object-oriented databases and the flexibility

of distributed systems are also being applied to digital libraries and introducing radical changes in the intellectual practices and structure of institutions, economics and social organisation at the level of transparent interaction, taxing mechanisms and sharing of documentation repositories.

As we stated, a digital library system should deal with several multidisciplinary aspects. In this paper we are primarily concerned with technological aspects related to the distribution of the digital library services over the Internet.

In the next section the functionalities of a Virtual Digital Library are described making references to the user requirements of this type of service. Section 3 presents the service components and how they relate. The repository service is presented with detail in section 4, together with some relevant aspects of the service specification and of the service distribution. Finally, in section 5 some conclusions drawn and future work issues are presented.

17.2. FUNCTIONALITIES

Today, the Internet is present not only in the large modern cities but also in small villages and, in that way, could be one of the most important ways to bring information to everyone.

In the situation of network globalisation and constant human mobility, people feel a natural interest in the possibility of, using the Internet, having services, such as distance learning, auto-formation or co-operative work, available away from home.

The functionalities that a Virtual Digital Library service should provide to satisfy the needs of the different possible users, such as companies, education institutions, students or teleworkers may be summarised as follows:

- To be an effective library, it should provide ways for users to access relevant documents in their working areas.

Search is a time-consuming task under any circumstances. The user needs to find something quickly and have some immediate success to maintain his motivation and engagement. It is required that the user could choose a set of options to better specify what he wants to find in the digital library. These options include the choice of in which sites should the search be performed, of the language of the documents, type of document, date, etc.

- The user should have the possibility of walk through the contents of the digital library at different levels of granularity. The digital library should provide browsing methodologies that could be followed easily by their users. Ergonomic and easy to use interfaces are obvious requirements of the service.

- The users should be able to retrieve documents from the document repository. With the growth of Internet and the increase of its utilisation, the transmission time could become a problem. A requirement presented by the digital library users could be the transmission of compressed data. The user should then have the possibility to decompress the information to use it.

- The users should have support to develop new documents, (either afresh or improving existing ones) and should be able to upload new material to the digital library.

- It is required that the system should have administration support. Thus, the system will be able to add, modify and delete user information, control access to documentation and monitor user actions. For security reasons it is necessary that user transactions are monitored and recorded.

- Security could be a priority since the access to some documents could be restricted to a set of users to protect restricted information and to protect

intellectual propriety rights and copyright. As the information will be transmitted across public networks, the encryption of data during transmission could be an important requirement.

- The library and its contents will certainly be distributed, but this must not be apparent to the users. One of the main concerns should be to allow users to have easy access to the distributed sites of a library and to different types of documents without having to know the configuration of the system or having to purchase extra software or hardware for their desktop.

- It is assumed that users will be mobile and thus will not always access the service from the same computer. Access to service facilities will therefore be user-focused, rather than computer-focused.

- One of the principal requirements of a distributed service over the Internet is platform-independence. Keeping the service platform-independent should contribute significantly towards reducing development and maintenance costs. Institutions willing to adhere to the service will want to re-use their installed infrastructure and not to invest in the update of their computer systems. The use of well-known technologies so that end users are able to work with well established, familiar interfaces is therefore a requirement for the system. Any other technologies should be hidden and should not imply purchasing extra software or hardware for the client side.

- A real problem in telework and distance learning systems is the lack of collaboration among the users. Conversation is a key component in joint work. Thus, the on-line communication between the users is a requirement that the service should cover. This will encourage the users interaction and a better way to work. The communication between users could be supported by images (with videoconference systems) or by text (with chat or whiteboard systems).

- With the increasing availability of input and output devices in multimedia workstations, the supply and demand for non-textual information sources is likely to grow exponentially in the near future. Non-textual information such as sound recordings, images, video, and scientific data require considerably more storage per item. For example, a page of text contains only 4,000 characters, whereas a single image requires roughly 300 KB, and a minute of uncompressed digitised video requires over 500 MB. In this way, a large volume of multimedia data will be held in the repository; and the system must be able to cope satisfactorily.

- With the growth of commercial utilisation of the Internet, accounting and billing mechanisms could be a requirement of the system.

17.3. ARCHITECTURE

The great mobility of the human resources of today's enterprises and the increasing geographic spread of institutions and workgroups justifies the investment in the research and development of telematic systems that allow the integration and co-operation of people in the production, management and storage of information. The next step in this direction is the specification of architectures, tools and software components that allow the implementation of co-operation platforms. In this section we present a specification and the implementation of an object-oriented architecture of software components that could be used to construct a Virtual Digital Library, an environment in which the users could meet and produce, search and retrieve

multimedia documents. This environment would provide also access to tools and open spaces that would permit and stimulate the co-operation among use\rs, independently of the users platforms.

to build a Virtual Digital Library. This virtual building should not only behave as a real library, in the sense that it would cover the specification of a true library, but also the specification of one or more of the following
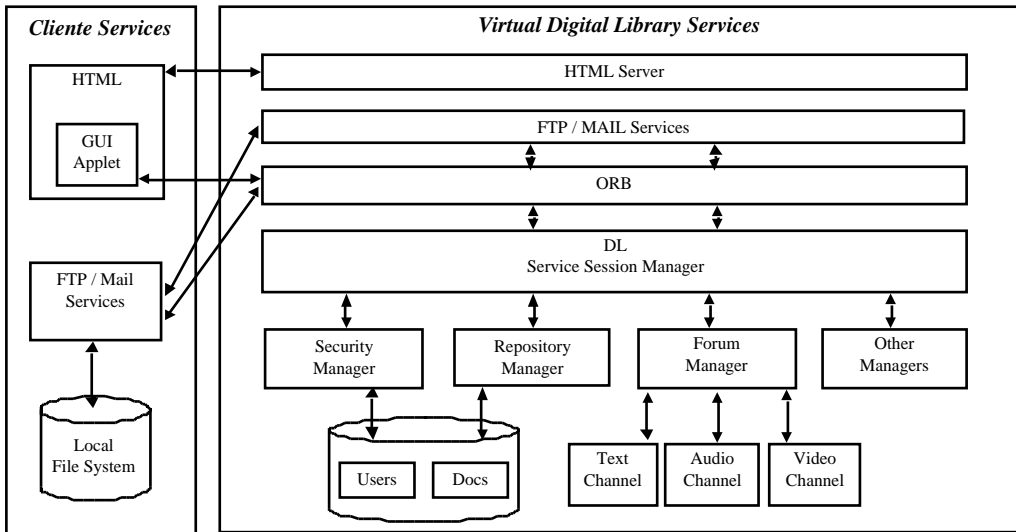
Figure 1:Virtual Digital Library Service Architecture

The focus of this Virtual Digital Library service should be to exploit the possible addition of co-operative functionalities/services to a virtual working space that would adapt to the users access point through mobile and intelligent agents technology.

The paradigm proposed here for this service defines a building that is made of flats and/or rooms where people can meet simply to talk about predefined topics or to work on joint projects. This building paradigm also defines security levels that should be specified in such an open way that several services helpful to users telework meetings could be added to that architecture as a simple cog into a big machine.

17.4. REPOSITORY SERVICE

The idea is to define an open architecture of software components, which could be used

services that could be added to that architecture (Figure 1):

- Control permissions to add/remove rooms to/from a building;
- Security control over people accessing buildings, rooms and data/files;
- Private exchange of messages between users in the same room;
- Rooms with shared brainstorm blackboard;
- Co-operative browsing facilities;
- Hypermedia documents authoring;
- Managing hypermedia file/document versions;
- Video/Audio/Text conferencing among users.

In this section we present the specification of the repository service distributed architecture and some implementation aspects related with the service distribution.

Figure 2 gives the partial OMT[2] object model of a Virtual Digital Library repository and how a user can connect to it. The service distribution is represented by the multiple Service Access Points and by the multiple Service Sites. A user accesses a Service Access Point and a Session is created. This Session controls the user identification and offers a set of facilities to the user. According to his permissions, the user can or cannot request these facilities. The Session evokes the execution of the facilities in one or more Digital Library Sites. Each site has a repository with two types of objects: users and documents. The users information has to be maintained so that the service could check the users permissions to perform service operations. The repository processes all requests and retrieves the answers to the Session. The Session communicates the answers to the users through the service interface.

Java[3] applets and CORBA[4] are two main technologies well suited for building distributed applications providing access to remote repositories[5]. This happens because such applications are driven by their interaction with the users, who invoke operations over remote databases. These operations are implemented by server software residing on remote host computers. The users are not logged into the server host,
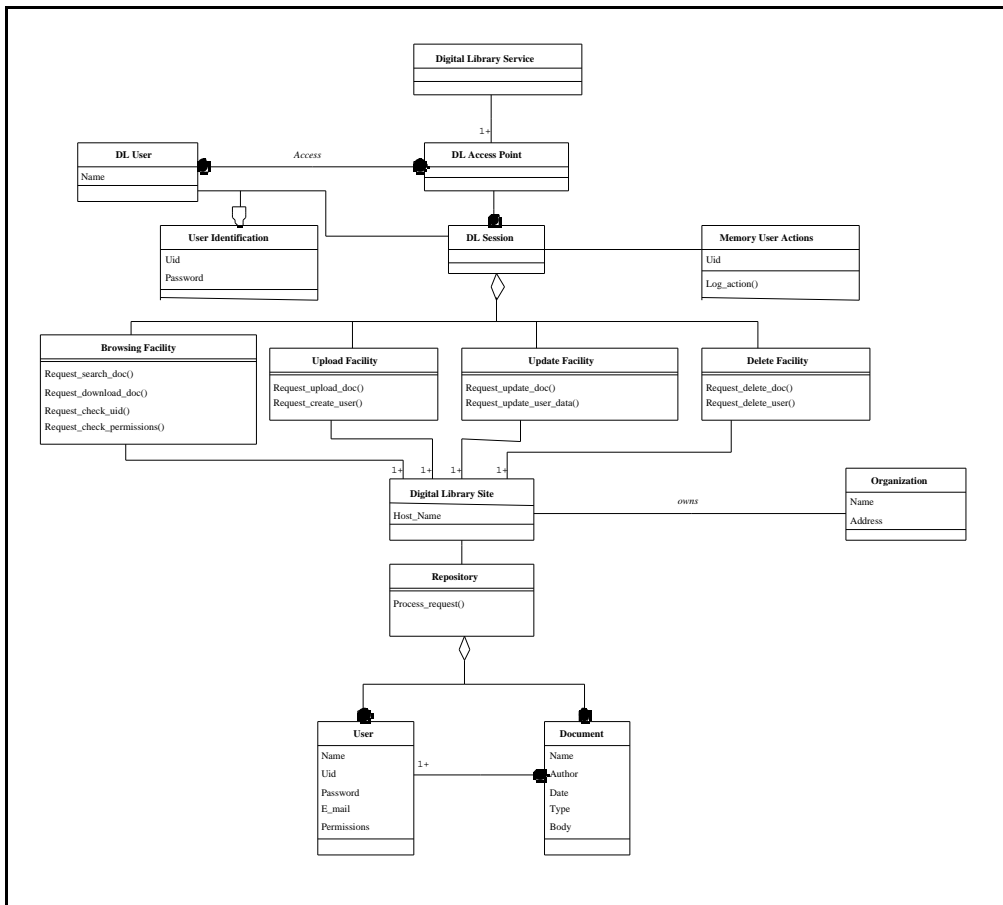
Figure 2: Partial Object Model of Virtual Digital Library Service

but interact with client software running on another host – the client host.

The client software takes the form of a downloadable CORBA enabled Java applet which provides the users with a graphical user interface (GUI) that accepts user requests and displays information back to the users. The server software takes the form of a Java application and provides the main application services based on data. This application supports mainly information retrieval operations, for database access, and resource management operations, for document management.

In this architecture, which is being implemented for a Virtual Digital Library document repository service[6], CORBA was chosen because of its advantages of transparency and suitability for heterogeneous environments. CORBA usage also avoids the direct use of sockets and keeps the advantage of automatic download of the user interface via WWW. Java was used to develop the client side.

Figure 2 illustrates the Virtual Digital Library distributed document repository architecture in which all of the user-side client software is implemented as Java applets that in turn use CORBA for performing remote operations with the other application software components. The user transparently downloads the applets when they are needed and the applets execute within the browser Java Runtime to present a GUI to the user.

From this point on, the Digital Library user makes requests via the GUI which result in the applet invoking methods on remote objects via the ORB using IIOP to take advantage of Internet connections. These remote objects may be instantiated in remote object server programs and may perform queries to the database and receive results that are passed to the invoking applet via the ORB. The applet receives the results of its remote invocations and displays some of them in the GUI and some in a dynamically
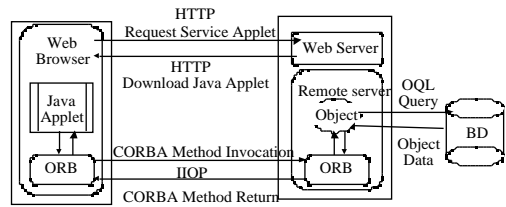
Figure 3: Digital Library Architecture

generated WWW page that is presented to the user. This HTML page contains links to the document entities that the user might want to download from the server. These entities can assume the form of various types of documents from the Digital Library, such as papers, on-line lectures and others. The Digital Library Implementation Architecture assumes that these documents are stored as persistent objects in an OO database.

Figure 3 illustrates the possibility of having more than one physical database to store the documents. Using the CORBA Naming Service[7], the applet can first find which server or servers provide the methods that must be invoked. Then, the applet issues as many requests as required to find or retrieve information from the various available repositories. This requires that the repositories share the same architecture,
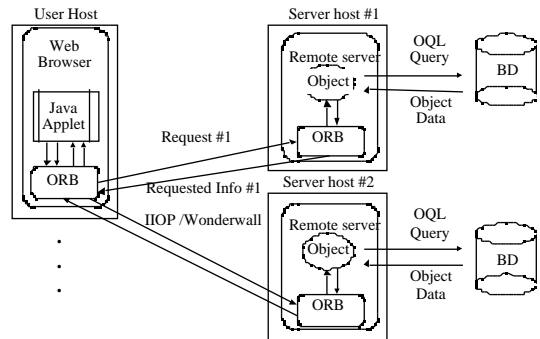
Figure 4: Digital Library Architecture involving different servers and databases

while containing their own set of unique documents.

It is also possible for the applet to invoke remote methods provided by remote objects residing in servers others than the one the

applet was download from if one uses an extended proxy mechanism provided by distributed software development tools such as the Wonderwall mechanism provided by Iona's OrbixWeb[8].

Some benefits of using this architecture can be identified:

- *Web based interface*, which allows the existence of an easy to use mechanism to access a distributed system, as well as removes the need to setup, maintain and upgrade client software,
- *platform independence* since a Java applet is used as the client software,
- it allows *greater control* over the applet based GUI design,
- *server-side software is less co*mplex since some functionalities are implemented by the client applet,
- client and server programs can exploit *multithreading*.

The documents download and upload actions can be restricted by current browsers policies concerning Java applets, which prevent the download or upload of unknown and possible hostile applets. This problem can be solved using one of two possible solutions: either using Email or FTP to send and receive the required documents by the user or using digital signatures based upon public key cryptography. The latter solution is a more promising one since it allows the browser to perform a security check on the applet and, therefore, allows it to execute the download and upload privileged actions. But since this solution is not currently widely used and has associated cost, the use of the Email/FTP solution was chosen for the current Virtual Digital Library service.

17.5. CONCLUSIONS

Digital libraries current research areas encompass diverse and complementary issues and multidisciplinary technological efforts, namely: user interfaces definition; processes of search and analysis of multimedia information; acquisition, management and publication of electronic multimedia data technologies; education and entertainment applications; distributed architectures and telecommunication services; accounting and billing services related to legal copyright aspects and information security issues.

Current digital libraries are multimedia information systems some of the times distributed infrastructures that support co-operative work and distant learning services. They usually act as an important resource in the co-operation and distant learning process. Thus we could see them as integrated tools for publishing and obtaining information and process management.

In this paper we have presented an object-oriented architecture of software components for a Virtual Digital Library. To achieve the main service requirements, some important features, such as flexibility, extensibility or platform independence, were determinant on the architecture definition.

There are several inter-operational and standardisation factors that push us to the installation and use of HTML electronic publications using data representation formats well disseminated (e.g. pdf, ps, mpeg) over the Internet.

On the other hand there are several advantages in the use of an architecture based on a CORBA/Java platform (e.g. OrbixWeb, VisiBroker, OmnyBroker, JDK1.2): the Web technology is well disseminated and is well suited for the deployment of such a system; the distributed systems are transparent and easy to use and access; there is no need to setup, maintain and upgrade the client software; the platform independence of clients is guaranted; a greater flexibility exists over GUI design (applets); the server side software is less complex than usual; the client and server programs can explore multithreading. Additionally the use of an OODBMS (Object Oriented Data Base Management Systems)

can overcome the relational model limitations regarding the management of multimedia data, and allows the development of databases and the programming of database applications using the same Object Oriented languages (e.g. Java, C++). This simplifies greatly the task of the application programmers in the sense that they manipulate the same concept (the object) at different levels: at storing level (persistent storage); at processing level (application); at presentation level (user interface). Other required features supported by these systems are: the support for Java applets (that meets new ODMG 2.0 Java binding - compatibility for distributed computing); the possibility to control transactions; the security control management (user access, object lock, etc); and finally the existent management tools dissemination. These principles justify the use of an OODBMS for the persistent storage of digital library multimedia documents.

Our main concern was the specification of a client-server architecture for the implementation of the Virtual Digital Library services over the Internet. We are currently developing security and repository management services for such a system. Several other services could be developed and included to enrich the digital library environment, using emergent software component architectures such as CORBA, Java Beans[9], and agent technology, among others.

Future research work will continue to focus on several relevant aspects such as: new intuitive, friendly and flexible interfaces to promote information consulting using virtual reality and assisted intelligent browsing through content description and virtual agents; virtual browsing environments and educational methodologies and applications to improve the methods of knowledge communication and ways to overcome the complexity inherent to the diverse areas of human knowledge; new and powerful

support services for distant learning and co-operative work through the use of distributed architectures for multimedia communication information systems; deployment of automatic managing system to support the acquisition, cataloguing, processing and publication of information, among many others.

17.6. ACKNOWLEDGEMENTS

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18. "WEB-ON-A-DISC" – AN INNOVATIVE USE OF THE WEB ON CD-ROM - APPLICATIONS IN SCIENCE EDUCATION

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Abstract – **We have developed a series of CD-ROMS that use HTML as the basic authoring language. This innovative use of the web has allowed us to use the simplest of languages to perform quite complex tasks. We developed our first such disk in 1995 and to date 4 CDs have been published in a series aimed at the scientific field of CYTOMETRY. The disks had 5 major goals: i. to assist scientists to find material that was very difficult to find on the web ii) provide an easy to use system for distributing scientific material iii) provide a low cost educational tool iv) create material that was cross-platform compatible v) link the material with the WEB so that it could be somewhat interactive and to some extent updateable. So far we have distributed 4 prototype disks with the last 2 having 5000 copy worldwide distributions each. Disks were distributed at no expense to the users. This paper will discuss both the concept of using "*web-on-a-disc*" concept, plus the impact this program has had on the field of cytometry, and its potential in science and other areas.**

18.1. INTRODUCTION

The web appears to have been with us forever. The fact is, it is one of the fastest growing dimensions of the computer age. Just 4 years ago, virtually no one had heard of the WEB or understood the impact it would have on every field of learning, entertainment and information distribution generally. In the United States alone, there are over 61 million regular computer users of the Internet. The size of the Internet traffic is now growing at an alarming rate. It is doubling every 100 days. This has brought with it advantages and disadvantages. There is now an enormous amount of information available on the web. However, one of the most difficult problems facing users, is the ability to sift through the information to extract the relatively small useful component. Our initial goal in developing a web based CD-ROM was to create a tool for scientists that would save them valuable time, place key information at their fingertips, and create an equally exciting and interesting adventure as most people seem to enjoy in "surfing" the web. There are, however, many other applications of this concept.

18.2. THE "WEB-ON-A-DISC[TM]" CONCEPT

Initial efforts at placing HTML on a CD-ROM and using the material "off-line" failed because the web was not originally designed to perform this simple task. We attempted to use the original public browser "Mosaic" to operate as a hypertexting tool for stored material on-line, but an unrecoverable error message cause the system to lock up if an active internet session was not encountered. The original developers appear to have not for-seen the possibility of using HTML as an on-disc authoring system. Once this problem was resolved we used HTML programming to create an entire CD-ROM complete with an index, hyperlinks throughout, graphics and links to actual Internet sites. The disks were useable in both IBM-PC, Macintosh, and UNIX computers since HTML is not platform specific.

18.3. THE PURDUE CYTOMETRY CD-ROM SERIES

WE have to date, distributed 4 distinct CD-ROMs with material related to the scientific field of cytometry [4-7]. Cytometry is the study of cells and their various properties, and involve the disciplines of immunology, pathology, physiology, biomedical sciences in general, biomedical engineering, genetics, cancer and many other fields. The primary objective of our Cytometry series was to consolidate the information available in the field into a series of resources, which were universally available to all scientists regardless of the type of computer, word processor, or software they had available.

All code was in HTML and initially was all written in longhand by technicians, students and staff from our laboratory. No programming tools or guidelines were available and so we created a series of rules. Initially these rules were based upon the capability of HTML. Only GIF files were used (initially only JPG and GIF were readable on the web). All filenames were required to be in 8x3 format because of a windows 3.1 requirement and that was the most extensive operating system in use. No filename could have more than 3 character in the suffix, so HTML files were truncated to HTM. All directories were required to be relative, rather than absolute addresses. No more than 7 directory levels were allowed. These decisions were based upon ISO 9960 standards.

Despite the widespread use of long filenames, we still require the above standards, since this makes the discs universally readable even on older computer systems. Restricting the number of directory levels also keep the system backwards compatible. None of these aspects adversely impact the programming of "Web-on-a-disc^{TM}"code in any real manner. While it

may be more inconvenient to use shorter file names, the increased compatibility is more important.

Developing a fixed structure for "Web-on-a-disc^{TM}" CDs is vital. This must be considered prior to the programming of the disc. For example all images for a section could be placed into a directly called "images". If the disc is structured somewhat like a book, it could have a series of chapters, each of which could contain images, data files, videos, sound etc. Each should have its own subdirectory and the structure should be common throughout, particularly the directory dept. Of course, creating a CD-ROM version of a book in the same structure as a book is designed, is relatively useless and is a poor use of the HTML capability. It must have many hypertext links, additional components (sound, video, animation, etc) and be structured to take advantage of the electronic media. Once code is completed, it is vital that every link should be checked. Today there are automatic checkers available that will notify the programmer of incorrect links.

Figure 1-These 4 CD-ROMs (Vols.1-4) have been distributed to the scientific community free of charge in an attempt to demonstrate the use of HTML-multimedia WEB-hybrids as an authoring process for scientific data and general information.

18.4. HYPERLINKING MATERIAL

The true advantage of using HTML code for CD-ROMs is the fact that with a single command, a link can be made across the CD or to the outside world via the Internet. Indeed, all of our CDs contain direct links to active web sites, and further, we also maintain an error register on our web site, that provides up-to-date information on any errors that are identified on the CD-s after pressing. In some cases we can provide simple fixes to problems that occur. Links can be repaired where incorrect information was included on the disk, or substitute instructions can be provided for absent or mislabelled files.

18.5. APPLICTION TO ELECTRONIC PUBLISHING

There are many possible tools for electronic publishing. Most require a considerable knowledge and experience before the user can adequately produce usable material. Of course, most authoring packages are very powerful and can perform significantly more tasks that the average user will ever understand. One medium is interactive video. There are many advantages to interactive video, however traditionally this required large expensive optical disks called video disks. These required disc cutting machines that cost at least $20,000. Our first attempt at interactive video was in building a simulated flow cytometer[1]. However, the project was stalled by the excessive cost of cutting master disks, and the difficulty in editing the material. Other attempts were at using authoring systems to create interactive quizzes [2]. These were relatively successful, but had a limited application.

Our more recent attempts at using HTML programming have proved more successful for several reasons. First, and foremost, is the relative ease with which material can be programmed. While a more limited

capability, our goal was to emulate the huge success of the web. Our initial efforts were relatively simple in that only very basic HTML commands (about 15) were available. As HTML has matured, so too has the level of sophistication that is possible with this technology.

Another significant feature of web publishing using "web-on-a-disc"[TM], is the low cost of distribution. CD-ROM pressing is now very inexpensive (less than $1 per disc) which means that large quantities can be produced at low cost. The final factor of importance is the fact that these CD-ROMs can be operated on any computer with a CD-ROM reader, regardless of the operating system being used. This allows a single platform to be created with universal impact.

18.6. OTHER APPLICATIONS IN TERTIARY EDUCATION

We have recently begun using WEB-CD-ROM hybrid systems where material not normally suited to downloading on the web is placed on the CD-ROM. An example of such material would be large videos, large files containing 3D projections or rotations, complex animations, large images, or large data files. These large files, while easily downloadable on fast T1 lines, are not downloadable at all on most modems. Thus in the field of image analysis, we are currently using CD-ROMs to distribute very large video files, software and other related files.

We anticipate that multiple class materials could be placed on a single disk and distributed, for instance, within an entire educational establishment. This would reduce costs and increase availability of useful material. We are currently experimenting with this by linking to CD-ROMs from our website [8].

18.7. CLASSROOM USE OF CD-ROM-WEB MATERIAL

The primary advantage of using HTML programmed CD-ROM material is that almost any animation or video package available to day can create HTML based code more easily than learning the rather complex authoring packages such as *Authorware* or *Macromedia Director*. While these are powerful and excellent packages, they require a considerable amount of time to learn and a continuous interaction to maintain those skills. Most who don't consistently use these tools rapidly lose their ability to apply them. On the other hand, HTML programming is difficult to forget once mastered, and has the added advantage of always have the source code available if one forgets an operation.

This brings in an important observation; most professors have little time to master complex authoring programs. Using HTML, one can produce material almost immediately in a relatively expert fashion, particularly considering programs such as MS Word, PowerPoint and Excel all have output capabilities to HTML code which requires absolutely no expertise or understanding of the code itself. Transferring this to CD-ROM is not difficult, and creates an easy mechanism for mass distribution of educational material.

With new tools available, such as Dynamic HTML, JAVA and the host of "plugins" - animations, videos and sound are all relatively easy using HTML. Thus CD-ROM material authored by HTML can be as exciting as web based material currently available on line.

18.8. CONCLUSIONS

In this paper we have described a unique application of web based technologies. Our group has now developed considerable experience in using these simple tools for educationally useful tasks. Scientists have discovered that the tools of the Internet are most useful and should be utilised to the full [9].

We have now distributed over 16,000 disks worldwide, to date, all free - in an attempt at developing a relatively simple, low cost educational forum, which is universally compatible with essentially all available computer systems. This cannot be said for many software packages or applications. We have also discussed the philosophy driving these developments. Tertiary education is a rapidly changing environment and to some extent, our role as teachers must change as well.

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19. "BIOSCOPE" – AN NSF FUNDED PROJECT TO DEVELOP INTERACTIVE BIOLOGY CDs
LINKING STUDENTS AND SCIENTISTS VIA THE WEB

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Abstract – Nine interactive biology learning programs designed as hybrid, WEB-based CD-ROMs (Web-on-a-Disc[TM])# will be developed for high school biology students. Based on typical introductory biology microscope slides, the CDs will encourage students to develop questions as they progress through increasingly complex explorations of images and data collected from state-of-the-art imaging technologies. Familiar light microscope images will lead to electron microscope (TEM - SEM) images and the newer technology of 3D laser confocal and fluorescent microscopy and laser flow cytometry. Students will access images and data not only on the CDs, but also on the WEB, with access controlled via JAVA- and HTML-based WEB programming using newly developed long distance learning WEB protection schemes developed by our group. The CDs will be designed with "handles" (culturally relevant real-world examples) that will link the images, data, and questions to students' experiences. An interactive WEB site maintained at the Purdue University Cytometry Laboratories (PUCL) will facilitate the establishment of student-scientist partnerships and communication among all participants, to ask questions, test ideas, and defend conclusions.

The "Web-on-a-disc" concept has been submitted to the Purdue University Patents & Copyrights Office for trademark protection

19.1. INTRODUCTION

We are concerned that there is little depth, interactive nature or use of cutting-edge imaging technologies in high school biology. We proposed to develop a complete new set of material using currently available *state-of-the-art* technologies where needed, and an extensive use of image analysis tools as appropriate. Developers will be biology teachers from urban, rural, and suburban schools, science educators, and research scientists. An initial consortium of three master biology teachers, seven scientists, and three science educators plus professional staff and students will develop and pilot the first CD. A second group of ten teachers will field-test the discs and have the opportunity to join the development team. Each year more teachers and scientists will participate. CDs focused on cellular structures, cell membrane physiology, cell cycle/genetics, plant tissues, animal tissues, human tissues, protists, fungi, and monerans will be developed. More than just simple picture books, the CDs will take advantage of students' fascination with a questioning environment and the WEB to foster investigations of structure/function relationship. Students will rotate, manipulate,

and "walk" through a virtual reality of imagery.

All materials will be developed under HTML using JAVA, the latest WEB technologies, and the *Web-on-a-Disc*™ CD-ROM concept developed and already proven at Purdue[1-4], which will allow participating schools to communicate through an interactive WEB site. Supporting lesson plans and software will be available for efficient active use of the *Web-on-a-Disc*™. A video-linked development lab supplying an opportunity for student participation in the development process and pilot testing will be established initially at a local school near the university. A second school in an urban setting (Gary, IN) will then be networked for pilot and field-testing. Practical curricular materials will be produced which will bring life to cells, tissues, and microbes using new technologies, which our future scientists (these students) will consider basic.

19.2. THE USE OF TECHNOLOGY

The *National Science Education Standard - Content Standard A*[5] which states "*..new techniques and tools provide new evidence to guide inquiry...,*" describes a seminal feature of this program. This standard further recognises a basic tenet of scientific research, that "*..the accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used....*" This proposition is fundamental to our own scientific research achievements. *The Indiana High School Proficiencies - 2.4 Technology and Science*[6] expresses this perhaps more forcefully: "*...New technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances....*" These imaging tools, based upon the innovative *Web-on-a-Disc*™ CD-ROMs, will be applied across the biology and life science

curriculum, with special emphasis on high school biology. This technology will be used to establish meaningful **student-scientist-partnerships (SSP)** to allow **all** students, not just the lucky few, to have active involvement with other students and scientists. The starting point for these projects will be the very light microscope slides so commonly used throughout the biology curriculum yet so often difficult to resolve or visually understand. The CDs will encourage students to travel through ever increasing levels of complexity with the aid of the most recent imaging technologies and scientific material used by practising research scientists. It is ironic that the writers of the standards have recognised the vitality of *state-of-the-art* technologies for teaching students. Many research scientists themselves fail to achieve the funding necessary to obtain and exploit these tools. This project, however, guarantees the availability of such technologies as our laboratory has an excellent array of flow cytometers, confocal microscopes, image analysis tools and computer technologies.

19.3. ASSESSMENT

Assessment tools utilising **National Standards Frameworks** will provide justification for decisions taken. Assessment will be embedded in the CD and modern assessment tools will be provided for the teacher. The software will allow teachers to track student use of the materials.

19.4. CONTENT AND PEDAGOGICAL STRATEGIES

A series of CD-ROMs, supporting WEB site, and ancillary materials will be prepared. These can be used in biology curricula wherever the microscope is used. Each CD will be a tool allowing students to study cells and tissues with modern imaging

technologies not normally available to high school biology teachers. In high school microscope lab activities, students customarily view and investigate a series of slides. Students often have trouble understanding what they see with the light microscopes available in high school biology classrooms. The image obtained may be unclear because of limitations in the instruments. Even with a reasonably clear image, students' limited understanding of the nature of microscopy and its artefacts may make interpretation difficult. The CDs will be designed to include all topics frequently studied with microscopes in high school biology and to encourage deeper study.

The *National Science Education Standards - Teaching Standard A*[5] addresses the issue of inquiry by students, stating that *"..Inquiry into authentic questions generated from student experiences is the central strategy for teaching science*." The concept that science should be "discovered," not spoon-fed, was recently exemplified in a *Science* article which described science as *"...organised wonder pursued by privileged hands*."[7]. These privileged hands have often been those of research scientists, creating hypotheses from observations and deducing truths from experimental studies. Using the technology's advanced imaging devices and interactive multimedia and WEB sites, high school students will have a unique and exciting opportunity to ask simple but important questions. They can pose hypotheses or create ideas. In so doing they are part of a process to "…*guide students in acquiring and interpreting information from sources such as libraries, government documents, and computer databases--or as they gather information from experts from industry, the community, and government...*"
Topics presented in the standard manner (textbooks, light microscopes, or electron micrographs) will be investigated in more detail using new technologies which will

give students the chance to pursue their own real life questions and make their own inquiries. They will also have the opportunity to question and confer with the scientific community on the WEB. We do not claim that students need high technology to learn. Clearly they don't. However, the highly defined tools familiar to practising research scientists can bring out many more possibilities for learning and questioning. The goal is *"authentic questions generated from student experiences."* The discs open many possibilities for asking "*What if*?", and in so doing allow the students to be exposed, of their own volition, to many exciting alternatives.

19.5. DIVERSITY

Teaching Standard B, requires teachers to "…. *Recognise the diversity in their classes and organise the classroom so that all students have the opportunity to participate fully....*" Material produced will have relevance for all students: underrepresented students, city, country and rural students; challenged as well as advanced students. A wide variety of teaching methods reaches more students with their wide heterogeneity of learning styles. The use of new and different technologies captures students who might not respond to standard methods. Computer technology is easily adapted to a classroom that includes students with physical or learning disabilities or students for whom English is a second language.
One particularly relevant aspect of vital importance to disabled students is the ability to fully participate. Teaching standard B further states that *"..students with physical disabilities might require modified equipment; students with limited English ability might be encouraged to use their own language as well as English...,"* something that can and will be easily incorporated into the philosophical backbone of this project. The standard also wisely suggests an

alternative; the utilisation of a variety of presentation methods including images, graphs, animations, and diagrams. *"All students will have opportunities to express scientific findings with graphs and diagrams to enhance written explanations...." M*any images and graphical tools will be used.

19.6. EXCITEMENT

This entire project is directed towards increasing excitement about biology. In the disc and on the WEB, students have the opportunity to investigate and *virtually operate* advanced imaging systems. In fact,

BioScope Initiative: InterativeCD-ROM Topic Areas: Slides Commonly Viewed in High School Biology

Topic	Slides	Structures	Physiological concepts
Typical cells	Prokaryote – bacteria Eukaryotes- plant - onion epidermis, *Elodea* animal - human epithelium	organelles, membranes, biochemistry, molecular models	membrane physiology, protein receptors, biochemicals such a molecular motors (dynin) organelle physiology
Diffusion Osmosis	Potato red blood cell purple onion epidermis	vacuoles, membrane-active transport structures	diffusion modeled (math) osmolarity, homeostasis, active and passive transport
Mitosis Meiosis	onion root tip whitefish blastula	mitotic spindle, cell cycle	cell cycle, cross over, birth defects, cancer, non regenerating cells
Viruses & Monera	viruses, bacteria: coccus bacillus, spirillum, bluegreen	cell structures, viral structures	movement, immunity, fission environmental monerans
Protists	*Amoeba*, *Paramecium, Volvox, Euglena, Chlorella*, diatoms, desmids, *Spirogyra*, radiolaria	key structures	the importance of algae in the environment, symbiotic relationships
Fungi	yeast, bread mold (sexual asexual) mushroom gills (probably *Coprinius), Penicillium*	reproductive, vegetative	disease, saphrophytic, food organisms
Plant structures	*Ranunculus* root cross section, monocot and dicot stem cross section, leaf longitudinal section leaf lower epidermis, pollen	tissue and cell types	relation to plant physiology histological procedures
Simple animals	hydra, O*belia* (medusa and polyp), *Planaria,* earthworm cross section, insect wing, insect head	various organs	environmental and economic processes
Animal tissues	bone, muscle, liver, kidney adipose tissue	cell, tissue, organ hierarchy	physiology of the structures

Table 1

Legend: *Table 1 represents a series of CD-ROMs, supporting WEB site, and ancillary materials which can be used in high school biology courses. The subject matter represents the areas in which microscope images are used. They are designed to fold into the teacher's curriculum at common points of interest.*

the very nature of the data-sets, investigations, and leading questions are all designed to increase enthusiasm for science in the student who would otherwise have no access to these technologies. The discs will be visually and intellectually fun.

19.7. ACCURATE CONTENT AND RELEVANCE

Another underlying relationship, which will be continually highlighted in the discs, is the concept of structure/function relationships. *Life Science Content Standard C*[5] in part reads *"Cells have particular structures that underlie their functions…."* *The Indiana Science Proficiency Standard*[6] is perhaps a little more detailed and in part states that *"…complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division…."* Our scientific team recognises the importance of understanding the relationships discussed. They do so in the knowledge that their findings will be subjected to rigorous peer review before being published. Accuracy of content is to be assured by a broad group of practising scientists and advisors.

We want students to exceed their current understanding of structures, functions, and techniques. Like art critics, picking up a piece of sculpture and viewing it from many angles, we want students to study in greater depth as recommended by the TIMSS study [8]. A sign of success will be the questions which students ask. Data logs of the questioning will be built into the software and be available to the researchers and the teachers.

19.8. CURRICULUM CONTENT

Table 1 demonstrates the range of content included in the BioScope Initiative. Each CD-ROM-WEB hybrid disc will cover one of the topics listed in *Table 1* which also identifies the key features and concepts to be taught. *Figure 1* provides a flow chart of the process by which a student identifies the material to be studied and how they might proceed toward a learning objective.

19.9. POTENTIAL IMPACT AND SIGNIFICANCE

The 9-12 High School Biology Student Target Audience

These discs are targeted to the introductory high school biology course. They may find application in earlier and/or later courses and eventually as examples throughout the entire K-14 community. The *Web-on-a-Disc*™ CD-ROM will impact students in several ways. Not all students achieve equally in biology, and the level of their achievement is influenced by many factors, especially the ability of individuals to understand, retain, organise, and use information associated with their learning.

Through the use of the *Web-on-a-Disc*™, each student will receive immediate assistance and guidance without necessarily having to wait in turn for the instructor's immediate attention, thus saving valuable time for both student and teacher. The *Web-on-a-Disc*™ CD-ROM will provide individualised learning accommodating students at all ability levels; and as a result, the instructor can observe and provide individual guidance to all students **as needed** as well as have more time to devote to those who require intensive assistance.

• Students will have a better understanding of standard microscope images and be better able to integrate these into their overall picture of the world.

• Students will become increasingly self-confident as they experience personal satisfaction and a sense of achievement in
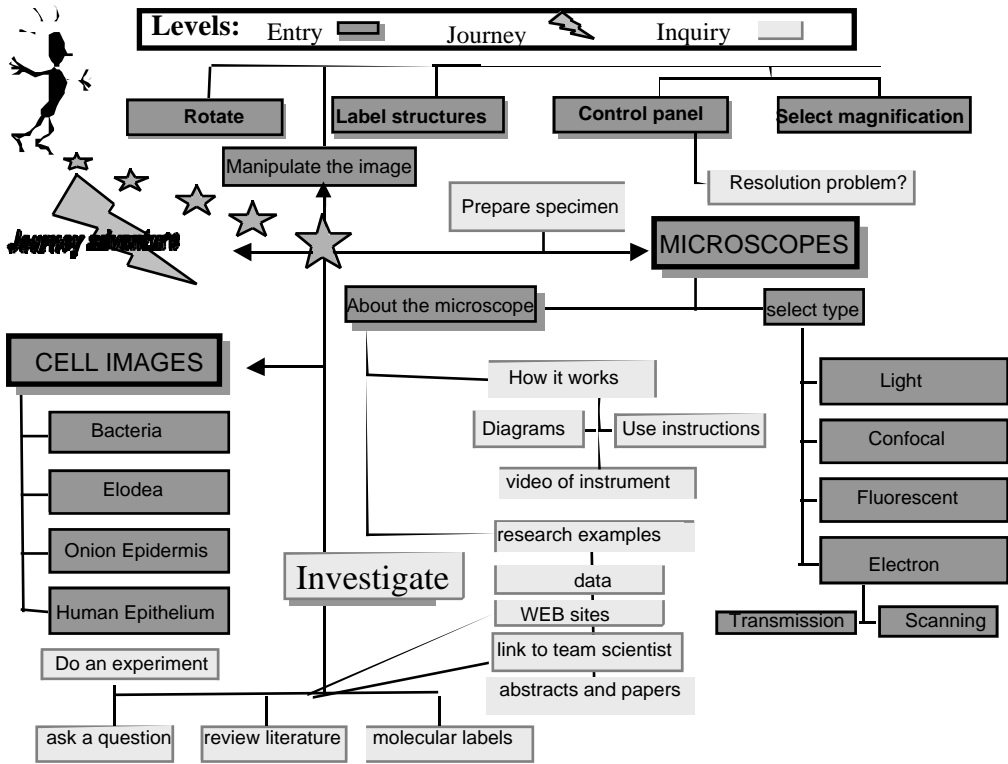
Figure 1

Legend: *A flow chart of the possible paths which students can take through the first disc. Students are presented with a number of icons offering the choice of basic cell type (e.g. bacteria, Elodea, onion epidermis, human epithelium), manipulations (e.g. rotate, label structures, magnify), and tools to use (light, confocal, fluorescent, or electron microscope). The cell types represent typical eukaryotes (plant and animal) and prokaryotes. Data appear as well as images. Early in the quest there will be a suggested (highlighted) pathway to follow, but the students may choose otherwise. Students are encouraged to go to the inquiry level which involve three additional sections. 1. Questions about how the cell structures apply to their everyday life, 2. virtual and real investigations which the student may construct, and 3. A presentation program by which the student or teacher may use the images and data to make their own seminars to the class.*

successfully conducting labs without having to request constant guidance.

• Students will have more **active** lab time, allowing them to perfect the manipulative skills that will be useful in other investigations; but at the same time,

they will absorb some of the feeling of how a research study is conducted.

• Students will become more familiar with the proper use of new technology lab equipment and laboratory procedure, because of the quantity and quality of labs they are able to perform.

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new technologies for higher
education

With the use of *Web-on-a-Disc*[TM] CDs, students of all maturity and ability levels will be able to work at their own pace when viewing microscope images. Lower-level students will benefit immensely since they can use the instructional material for reinforcement of basic ideas and knowledge in innovative and interesting ways. Those students who need to review labs several times will be able to do so on their own with the CDs. The *Web-on-a-Disc*[TM] CD can provide this learning opportunity because it is more exciting and visual, but also because it uses the format and medium now most familiar to students – the WEB. Advanced biology students may need to relearn as they move from one area of biology to a more advanced area. The *Web-on-a-Disc*[TM] CDs would be ideal tools for this purpose. Whether standing alone or serving as a supplement to laboratory experiments or as a tool for review, the *Web-on-a-Disc*[TM] CD will provide the opportunity for reinforcement of skills and knowledge for all students.

Other uses of the *Web-on-a-Disc*[TM] CD-ROM include enabling a student who misses an actual lab to receive the experience and benefit of that lab using the interactive multimedia alternative, or anticipating material to arouse student interest in an upcoming lab, lecture/discussion, or project. One of the greatest impacts of the *Web-on-a-Disc*[TM] CDs is the power that it will give students over the content and pace of their own learning.

19.10. CONCLUSIONS

In this paper we have discussed a new project that is being implemented by our university faculty for high school biology students. Our goals are to utilise the high quality research environments to produce material that far exceeds the quality and depth of material available to day for our high school students. All the material will be based upon *state-of-the-art* multimedia-interactive technologies and will be distributed using the web and other technologies. Further information can be obtained from our website [9]. The primary consideration will be the students learning experience. Teachers will be integral to the development process at all stages. We believe this program will make a significant impact on the science education of our students.

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20. WELLPATH
WELCOMING ENVIRONMENT FOR LIFELONG LEARNING IN PATHOLOGY

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Abstract – **The internet offers very attractive possibilities for the distance learning, the environment we are presenting uses the Internet as the way to make information available for students and teachers who need back-up material in their classes**

The environment includes different sections, each one for a different kind of material, as well as a database, search engine and remote upload system, among other capabilities.

20.1. INTRODUCTION

WELLPATH is a friendly virtual environment for training/learning in Pathology which is being used as back-up material in attending education as well as for Open and Distance Learning (ODL)

Its objective is to make multimedia training material available for trainers and learners, and in the future, to share this contents with other universities and organisations from Europe, forming a collaborative network.

This environment is based on a database engine called **Internet Training-Learning Management System.** This database stores the multimedia objects and allows access, navigation, searching and a set of functions as remote updating, reuse of the information, etc.

Depending on the user, who can be a student or an expert, different rights are given, all of them have reading rights, and the latter also has rights to add and modify the information introduced by him.

WELLPATH is already working in the University of Oviedo, and accessible for everyone in the Internet address http://www10.uniovi.es

20.2. EDUCATIONAL MODULES

Different technologies are used for the development of the material, as they are HTML with JavaScript and author tools as Macromedia Flash 2. The last one offers very good capabilities for putting interactive multimedia material on the Internet, allowing animations, movies and obtaining an optimal size of the result.

The environment contains different kinds of teaching material, and it is organised in tutorials, clinical sessions, seminars and short courses.

The **tutorials** are expositions of concrete themes, orientated at supporting of students of Medicine, they are objects with their own controls for navigating, animations, sound, notes and index. Titles available are Hypersensitivity Reactions, Neoplastic Transformation and Basic Mechanisms of Gene Expression.

These tutorials were developed with the experts A. Torreblanca and J. R. de los Toyos.

The **clinical sessions** are divided into four parts, clinical case presentation, discussion forum of the presentation, clinical case resolution, and discussion of the resolution. Both presentation and resolution include own reference to bibliography.

They are used with students from the second cycle of Medicine and for distance learning. At the moment we have 17 different cases.

These clinical sessions also offer a discussion forum, where the students can communicate with the *virtual tutor* or simply give an opinion, these messages are visible

for every student and tutor, this way, everyone is able to follow the previous conversation, and answer, if he has the solution.

The **seminars** are developed in web pages with HTML and JavaScript, used in the subject Anatomic Pathology, from the second cycle of Medicine. The structure of this module is the following: Learning objectives, Clinical history, Diagnostic reasoning and references, at present is available the first one: Respiratory Tract.

The **short courses** are modules with more information divided in sessions or lectures. The sessions are composed of objects incorporating images, audio, and animation displays with their own controls, similar to the tutorials.

At present a module about Gynecologic Cytology has been prepared, with the collaboration of the experts R. Martínez Girón and T. García Miralles.

This course is directed at training/learning of laboratory technicians and cytopathologists.

In the following illustrations we can see the home page of WELLPATH and one scene of the Hypersensitivity Reactions tutorial.
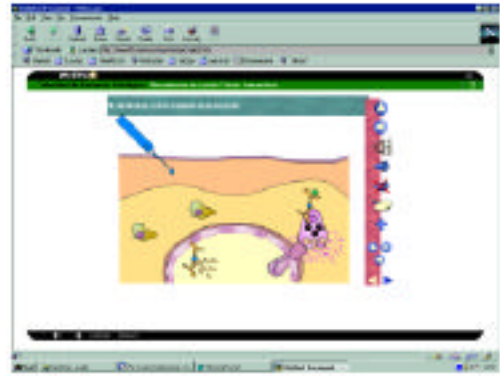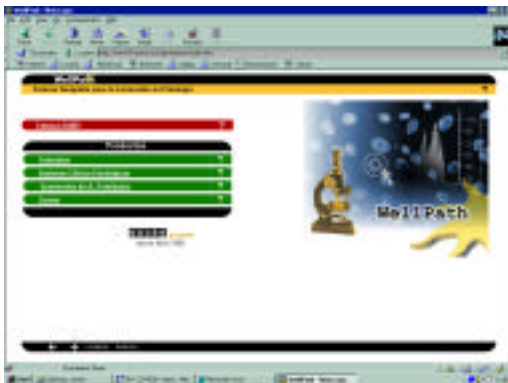
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21. BREAKING THE HYPERLINK, A SCENARIO-BASED APPROACH TO LEARNING.

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Abstract **- Object-oriented software technologies enable new approaches to learning.**

This paper tries to show how a story manager capable of building scenarios can be constructed. The paper also provides suggestions for structuring the content that the scenario is based upon.

In scenarios the student may explore a problem in many different ways and come to a deeper understanding of the material.

21.1. INTRODUCTION

Object-oriented tools and technologies have found their way to interactive media development.

Compared with the dominant timeline- and hyperlink-based learning-environments, object-oriented tools have an entirely different programming metaphor - and entirely different possibilities.

21.1.1. *Organisation of the material*

When looking at the organisation of content for learning material it is often presented in the classical "hierarchical tree structure" which works by the simple conditional "If score>50 then jump to...." or "if image x clicked then jump to ...."

Figure 1-A Traditional hierarchical organisation of content

This is natural since the early available technologies, hyper card and HTML for example, only supported the simple conditional or a linear time line with markers to jump to.

Object-oriented systems offer a totally different approach for organising content and, most importantly, the ability to create a world in which the student can explore the material and try different ways of coming to understanding and solving a problem.

Complex systems can be viewed either by focusing upon things or processes; there are compelling reasons for applying object-oriented decomposition, in which we view the world as a meaningful collection of objects that collaborate to achieve some higher level behaviour. (Grady Booch, 1994)

21.1.2. *The object-metaphor*

Objects know things about themselves and can do things.

An object *door* could <u>have</u> an attribute *closed* that may or may not be true, i.e. the door is open or closed.

In object-speak the door is also said to be the *parent* of the child-object *door-handle.* A door may have many handles, but a handle can only have one door.

The object *door* may also <u>know</u> that if the child-object *door-handle* is pushed and a force is applied to it, the property *closed* will change state, i.e. the door will be opened or closed.

This, *door-handle opens door*, is referred to as a *behaviour*.

The child-object *door-handle* may of course tell any or all other door-handles in the room, referred to as *siblings*, that it is being pressed by sending a *message* which may or may not trigger behaviours in other door-handles.

21.1.3. *Available object-oriented tools*

For interactive media authoring there are pure object-oriented tools such as *mTropolis* or *ClickWorks* but the commonly used authoring-tool *Director* has also been equipped with object-oriented features such as parent-child scripting and behaviours.

In traditional programming languages we find SmallTalk and C++, among many others, providing low level object-oriented programming capabilities.

For the World Wide Web the CORBA - Common Object Reference Broker Architecture - standard has been introduced facilitating a common object-oriented standard for clients to communicate with and through servers.

Many games and existing scenario-based learning material use software technologies developed exclusively for the production. In some cases this technology may be licensed.

21.2. SCENARIO-BASED ENVIRONMENTS

To build an object-oriented learning environment four things are needed:
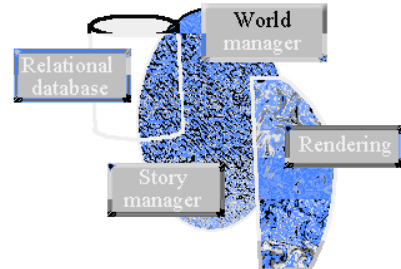
Figure 2-Components needed to build an object-oriented learning environment

- A relational database keeping track of the environment and capable of answering questions from the other components of the environment. The question "where is the dog" is answered "the dog is on the carpet in the livingroom in the house", following our object-oriented approach one could also say that "the house has the property dog".
- The world manager can be any object-oriented programming/authoring environment handling the objects the world consists of. This engine must be capable of handling inheritance, parent-child relationships, attributes and messaging that are part of the object-oriented programming metaphor.
- A real-time user interface rendering the world, its characters and the events taking place, i.e. all the objects and their actions. Rendering can be done in 2D for a screen or "true 3D" for a multiprojector cave or "cyber-helmet".
- A story manager responsible for creating a story that makes sense to the user and at the same time is interesting and pushes the story forward.

With this system in place we are now confronted with two very complex problems.

How is the story-manager to know what a good story is? And how do we create situations, scenarios, from which a student can learn something?

Lets start by trying to find the structure of the "good story".

21.3. A STRUCTURE FOR NARRATIVES

The narrative structure and devices in use by western stories have been analysed by the Russian Vladimir Propp in "Morphology of the Folktale", first published in Russian 1928.

By analysing more than 200 tales Propp identified 32 morphemes which may be present in a particular story.

21.3.1. *Propp Morphemes*

Some of these 32 morphemes identified by Propp are...

- Hero reacts (E) – reaction to actions of future donor
- Magical Agent (F) – hero acquires use of a magical agent
- Guidance (G) – hero is transferred, delivered or led to "the innermost cave".
- Struggle (H) – hero and villain join in direct combat;
- Victory (I) – villain is defeated
- Liquidation (K)   – initial misfortune or lack is liquidated
- Return ( ) – the hero returns;
- Recognition (Q) – hero recognised by mark, brand, or thing given to hero.
- Transfiguration (T) – hero is given a new appearance
- Punishment (U) – villain is punished;
- Reward (W) – hero is rewarded with kingdom etc.

Propp's analysis of a tale 133, a "double-move tale with one villainy", shows how

$$\beta^1\gamma^2\zeta^1\eta^3\delta^2\theta^3 A^1 \left\{ \frac{C\uparrow[D^1E^1\text{ neg.}]^3[D^1E^1\text{ neg.}]^3F\text{ contr}}{B^4C\uparrow[D^1E^1\text{ pos.}]^3[D^1E^1\text{ pos.}]^3} \right\} H^1\text{-}I^1K^4\downarrow$$
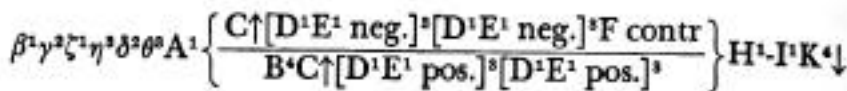
Figure 3-Double-move tale with one villainy - Propp, pp. 130.

Copyright   1968, Courtesy of the University of Texas Press.

- Interdiction ( ) – an interdiction is addressed
- Violation ( ) – interdiction is violated - villain enters
- Delivery   ( )   –   the   villain   gains information;
- Trickery ( ) – the villain attempts to deceive the victim to take possession of victim or victim's belongings
- Villainy (A) – villain causes harm/injury to family member
- Mediation (B) – misfortune or lack is made known and a call for help is issued.
- Departure ( ) – the hero leaves home
- 1st Donor (D) – hero is tested, interrogated, attacked etc., preparing the way for helper, donor

very complex narratives can be created using the   annotation   associated   with   the morphemes.

A story manager can be programmed from these Morphemes. The story manager would be able to structure and build a "good story" in response to the students actions and the behaviours of the objects in the world.

The story manager "knows", for example, that the Departure ( ) has to come before the donor (D) can approach the Hero.

However - if the story manager decided to play out the Trickery ( ) module there has to be an author responsible so that in this module the villain does, indeed, trick the victim of the story.

This leads us to how the Educator can use this structure and the story manager to communicate knowledge.

21.4. THE ROLE OF THE EDUCATOR

As an example I will take a course in advanced water purification chemistry.

Figure 4-The role of the educator in relation to students and story manager

The Educator writes a large number of story segments and index them according to their dramatic function in Propp's morphology. These story elements will be processed by the Story manager and played out to students in sequence according to their actions and the resulting events.

21.4.1. *An initial situation*

The initial situation, the set-up, consist of a time, a location and any number of dramatic functions, Characters.

The time could be year 250 BC, today or year 2800 AD.

The location could be Mars, Rome, Petersburg, the bottom of the Atlantic, or in a satellite orbiting earth.

For this course in the chemistry of water purification we choose a Mars-colony in the year 2012.

21.4.2. *Dramatic functions*

Characters are then selected according to their functions described by Propp; Hero-function, Villain-function and donor-function.

> *Functions of Characters serve as stable, constant elements in a tale, independent of how and by whom they are fulfilled. The number of functions known to the fairy tale is limited .* (Propp, pp. 21)

For this course we will need three characters: a Villain, a Hero and a Donor.
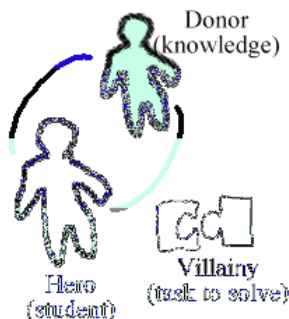
Figure 5-Characters in the scenario according to function.

1- The villain-function creates the task to solve.
2- The donor function provide the student with the knowledge necessary to complete the task.
3- The student will lead the hero-function through the scenario - alone solving the task.

21.4.3. *Equilibrium, violation and disturbance*

The Story Manager starts out by playing morphemes setting the stage for the action, introducing characters and the task to solve. -*"It was a wonderful day on the Mars colony. Amanda was taking care of the house, while her friends were away (β, Absentation) on a field-trip to the moon. John, the house-engineer, had told her to*

universit. sci. soc. 98
new technologies for higher
education

keep an eye on the water system (γ, Interdiction) since water purification had recently been adjusted. -"No need for that (δ, Violation), the water tastes as from a mountain-spring" thought Amanda as she took a glass of water from the fountain.

The Story manager then starts the action by playing morpheme A, villainy - something that disturbs the initial equilibrium. *Suddenly brown stinking water started pouring from the well (A, Villainy)*

21.4.4. *Hero-function - the Student*

The Student must now respond to the disturbance - perhaps by going to have a look at the Water Purification Machine. If the student choose to go to the purification machine the story manager selects a B C-sequence for playout *-Oh no! Amanda screamed (B, Mediation) as she started running (↑, Departure) to the purification machine. Smoke was coming out of the turbine. -How do I fix this? (C, Beginning Counter Action)*

The hero function - the Student - now drives the story forward to the resolution which in this case is finding an alternative way to purify water.

21.4.5. *Student actions*

The object-oriented programming-environment in which the scenario is taking place in enables the student to try different ways of handling the situation.

One could be to disassemble the turbine - but since we want to teach water purification the turbine is naturally beyond repair.

The student may also explore the environment looking for spare parts, but will eventually end up in the laboratory where all the tools for chemically purifying water is available.

21.4.6. *Introduce donor and test the Hero*

When the student has found the chemical laboratory the story-manager may introduce the donor - who has the knowledge/Magical agent the Hero needs to complete the task - by the sequence DEF.

A small Martian appeared outside the laboratory laughing -Er waap depa hembeep!!! (D, 1st Donor).

If the student responds to the donor in an appropriate way the story manager may choose to play out the request for help.

-Oh, stop laughing, Amanda said, -Show me how to fix this instead!

21.4.7. *The Magical agent*

According to storytelling conventions the martian/Donor will refuse to help until the student/Hero has proven herself worthy. After testing the Student by means of pre-knowledge, maybe through the Martian asking *-Don't you know the first law of thermodynamics? (E, Hero Reacts)* and the Student passing the test, the Story manager may select to provide hints or tools *(F, Magical agent)* for solving the problem - such as explaining the chemistry involved or showing drawings from existing water purification machines.

21.4.8. *The innermost cave*

With her new knowledge the Student may choose to proceed to *(G, Guidance)* the water purification machine without any help form a donor or otherwise. *(H, Struggle)* After fixing the water problem *(I, Victory and K, Liquidation)* Amanda/the Student is hailed by the whole colony and rewarded *(W, reward)* with a trip to Jupiter.

21.4.9. *The Dynamic Narrative*

Using Propp's annotations this story as played out above can be described as CD FGHIKW. The story elements,

the morphemes, identified by Propp can be used to create a dynamic narrative that allows for great degree of variation and exploration of the problem.

The complexities and variations on this scenario are endless and can be played out by the story manager recombining the morphemes provided by the educator:

· Amanda is forced to make her own tools in zero-gravity; MN (Difficult Task - Solution)

· She must go back in time to find the knowledge needed to solve the task; DEF (Departure– 1st Donor -Reaction- Magical Agent)

· Some Martians are nice, some are not, and different facts and 'donations' will have to be compared for their usefulness; LMNEx (False Hero - Difficult task - Solution - Recognition - Exposure o false hero)

· In case of failure to fix the water supply Amanda's friends arrive home to find the water purification machine broken and the house filled with Martians.

21.5. CONCLUSION

I argue for a scenario-based approach for learning in mediated environments such as the WWW, CD-rom or Virtual reality-environments.

The morphemes identified by Vladimir Propp enables a computer to act as a story-manager and from available elements build a coherent learning experience.

The structure also gives every educator the building-blocks to lean upon for "packaging" their knowledge in a new dress suitable for the new technologies and modes of communication.

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22. INTERNET TRAINING/LEARNING MANAGEMENT SYSTEM

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Abstract – **The Internet Training/Learning Management System is called RUBY (Recycling and Updating in Biopathology), and it is used to store and provide multimedia contents mainly for students of Medicine. It forms an environment that allows the remote updating and loading of the material, as well as functions to compose training sessions and multimedia objects.**

22.1. INTRODUCTION

Open and Distance Learning (ODL) is having a great success nowadays due to the continuous advances of information technologies. The main purpose of ODL is to improve learning techniques in terms of space, time, and contents. Although there are some web sites where it is easy to access information about the activities, meetings and training courses in Biopathology, we
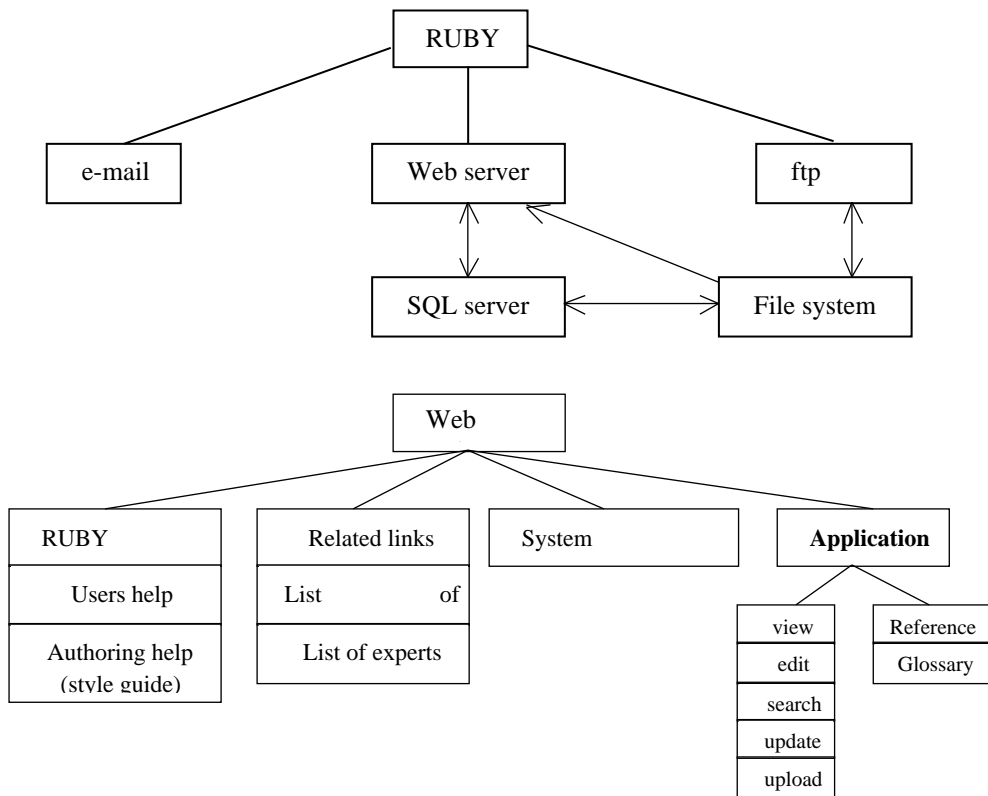
have not yet seen any distributed ODL environment across Europe in this technological area. With the aim to cover this detected need, we introduce in the framework of the European LEONARDO Programme, the project entitled RUBYNET (Recycling and Updating in Biopathology on Internet).

The resulting environment is located at http://ruby.quimica.uniovi.es.

22.2. SPECIFICATIONS AND FUNCTIONALITY

RUBY is based on the Windows NT 4.0 platform, using Microsoft SQL Server 6.5 in the database management, HTML and JavaScript for the web pages and ASP (Microsoft Active Server Pages) for the dynamic information. It also uses Posting Acceptor in order to allow the remote updating of the database contents.

The RUBY Interactive Training/Learning System is a new concept in terms of distance learning facilities, because experts from all over the world can make easily available all their latest investigations for the users of the system. Always following a predefined style guide that helps the experts to create standarized objects.

The information contained in the database is structured in programmes, wich are a group of related lessons, which are at the same time a list of objects. These objects are the containers of the information.

There are different types of objects, image, thumbnail, (group of images), flash (multimedia object from Macromedia), etc. All of them have the possibility to have audio, notes and data enclosed. And can be easily reused in different sessions.

This interface offers the possibility of looking for information in the database, copying and pasting objects from one session to another, editing and uploading the changes to the server. It also includes a complete access statistics viewer.

The classification of every object under institutions (with owner) allows the declaration of intellectual property and the correct distribution among several institutions related to the RUBY project.

The structure of this environment is showed in the previouse page.

22.3. WORKING ENVIRONMENT

The environment previously shows presentation web pages that offer the different programmes, statistics, related links, etc.

When the user chooses a specific session , the application window is showed, this window offers the rest of the possibilities of the system, depending on the user accessing.

The environment distinguishes two profiles, teacher and learner, the first one is allowed to create and introduce new objects and compose sessions, as well as to modify the material created by him. On the other hand, the user is only allowed to have a read-only access to the data.

A glossary of terms is also available and easy to update, as well as related links and references.

The communication between the learner and teacher is done by e-mail, the information of the creator of the object is available to the user, this way everyone can contact with him.

As we can see in the illustration below, in

eurecomfr v. inz. 98
new technologies for higher
education
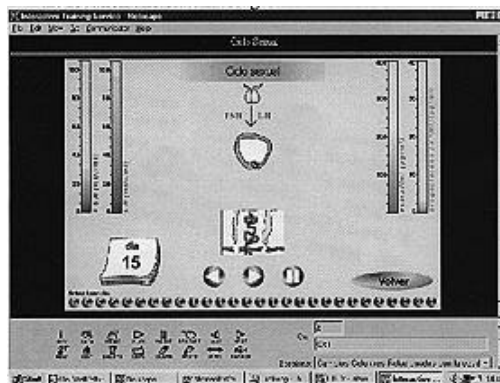
the application window there are two parts, the top contains the object and its title, and the bottom the menu and information about the location and state messages.

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universit_far in uz 98
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23. A TELEMATICS LEARNING ENVIRONMENT ON THE EUROPEAN PARLIAMENT: THE PARLEUNET SYSTEM

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Abstract **- The ParlEuNet (European Parliament Network) under development at the JRC is a Web based information system that will provide a multimedia educational platform for 10 secondary schools across Europe. Schools, teachers and pupils will use the system to teach to, learn about and prepare collaborative projects on the European Parliament. The state of the art Internet technology together with a set of pedagogical models will be employed to give live access to a highly dynamic multimedia database and promote a student-centred problem based learning. Web servers, browsers, digital certification, Java/JavaScript, URN and metadata technologies will allow an easy and transparent access to a set of resources. The pilot experiment under development will have to provide a validation platform to propose useful, transferable models on learning in a telematics environment for generalisation in a maximum number of European schools.**

23.1. INTRODUCTION

The World Wide Web (WWW) has shown to be a really good means of distribution and communication of multimedia content worldwide. On-line databases, data catalogues, advertisement services, data dictionaries and searching tools are commonly used within information communities today. Access to data and information has been made easy and straightforward. JRC ISIS has developed several dynamic Web based information system. These systems allow users to register and to submit and update information and data to a closely integrated database. The European Wide Services Exchange (http://ewse.ceo.org) developed for the Centre for Earth Observation has been very successful and is now used regularly by Europe's community of remote sensing specialits. Other systems are the G7 Environment and Natural Resource Monitoring (http://ceo.gelos.org) and the CEOS Information Locator System (http://cils.ceo.org). This last system has servers worldwide and allows for metadata synchronisation between servers. A feature of the EWSE is that each user has personal Web space where they can customise and update documents, images etc. This type of server is characterised by a "self populating database" whose content is defined by the users of the system.

The ParlEuNet (European Parliament Network) is the first European initiative to permit secondary school students to use state of the art networks and multimedia resources to learn about and do collaborative projects on the European Parliament. Internet connections, videoconferencing and a website containing a well-structured updateable multimedia database of educationally relevant materials will be used by students to access information on the Parliament, create their own projects, and exchange information and views with members of Parliament and students in other countries. The students' work will gradually supplement the website with educational

modules and resources which can be used by other students. The ParlEuNet system is under development at the JRC site and aims to provide a first prototype system by September 1998.

The objective of this document is to give a general idea of the ParlEuNet system showing its component parts, its possible uses and describe the basic techniques that will be used to implement it.

23.2. GENERAL DESCRIPTION

The ParlEuNet system will provide a multimedia database on the Internert to be accessed by 10 schools across Europe. The theme of the database will be the history, institutions and functioning of the European Parliament. The system will handle two types of information : reference material and dynamic educational material. The former concerns information and description of the European Parliament, the European Union and the Institutions of the EU; this will provide the basic set of data chunks which students and teachers can access and derive information. The dynamic education material contains the structured work defined by teachers (course work, assignments) and by pupils (projects, documents).
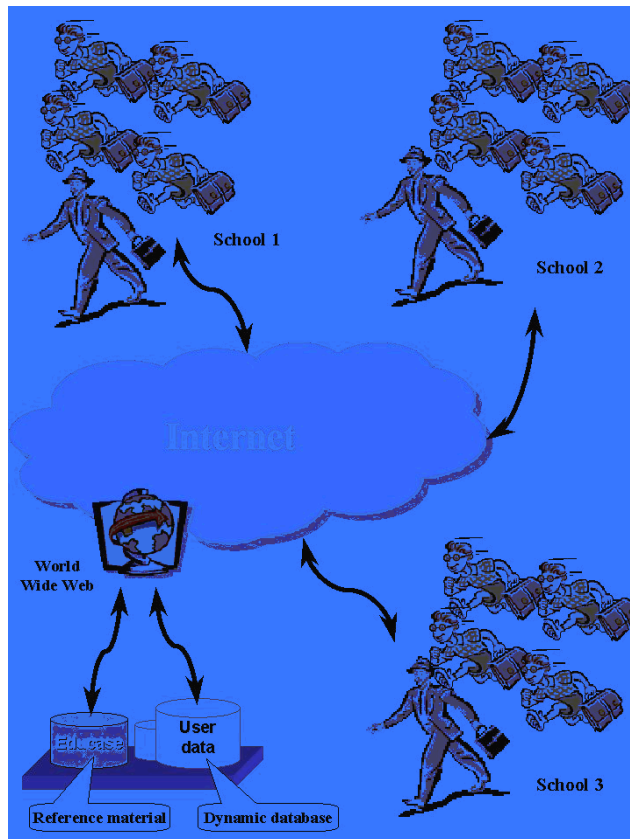

Figure 1 - Overview of the ParlEuNet system

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new technologies for higher
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The EDUCASE software under development by Arboth Learning will be used to store and retrieve all the reference material. Whereas the full dynamic educational content will be handled through a Web multimedia database. The EDUCASE software is currently a PC based system supporting teachers and learners. It consists of two tools. The first allows educators to enter course material into an MS-ACCESS database and to define structured course material using an editing tool. The second, Edubrowser allows learners to access the course material in an interactive fashion. The student can select different views of the material - through scenarios and through linked structures. The material is formatted in HTML and is supported by helpers such AVI video players. The system runs on a standalone PC and all the software tools are written in Visual Basic. EDUCASE was developed under a previous EU funded project and is now being applied for technical education and training by several industries companies. The EDUCASE software will be interfaced to the ParlEuNet system either using the ODBC protocol and/or a Web server accessable by users thorugh a Web browser.

The ParlEuNet system software will be tailored for the needs of students and teachers to exploit the new technology available to them through the Internet. The system will allow individual students to prepare and submit material visible by the teacher and/or other students. Groups of students will be able to prepare joint project work. Communications between schools, between students and remote collaboration on project work for students from different schools will be possbile using the system. ParlEuNet aims to provide a transparent and integrated interface to the overall material. Students will be directed towards EDUCASE for reference material about the Parliament and to the dynamic system for authoring and structuring project material. At the same time, users can access the Internet at large for acquiring additional data and material and insert into their work.

A tree view of available resources will be displayed into the entry page of each user, giving a easy to understand and straightforward way to navigate through databases. Any object within the EDUCASE system can be incorporated into student created material held within the dynamic database.

There will be a unique identification system to retrieve resources stored within the system. Both systems must support three languages : English, French and German. Users will have the freedom to feed data and search keywords in different languages. Each user into the system will be identified uniquely, giving them a persistent profile for long term and transient (session) information. Each user will have their own private area where upload and store data. Students and teachers will be able to interact with databases and construct and structure their work as HTML pages. A simple content editor will be developed to help users to fulfill this task. A hierachical structure of all data will be assured to give the possibility to school directors, teachers and the database manager to administer objects of a specific subpart of the system. Teachers will be able to delete or modify as well as insert resources into pupils private space. Each school and class will have their Web page where identity cards and information of all members are collected together automatically. The system will allow to build collaborative project pages between schools, between members of a particular school or pupils of a specific class. There will be a teacher or student that will own a project or assignment. An internal message system will be set up to allow student to student iteraction. It will be possible to set up a group work Web space to which a number of users can contribute. A bulletin board facility will be available to students to post a

message or a question and get back an answer by somebody else. A logging system will be built into the server to allow educationalists to analyse the reaction of students to the system. The logging will register the accesses to items and the chioces and constructs made by the students.

Downloading of large multimedia files over the Internet can be a serious problem. Therefore a caching system will be set up. There will be a CD-ROM issued regularly containg update from the database of video clips, sound files, VRML models etc. The system will automatically identify which data to load from the client CD-ROM and which other to load over the Internet. There must be an educationalist interface to allow researchers to analyse the activities of the students giving a full access to all parts of the database.

23.2.1. *Possible scenarios*

Based on the description given above a set of sample use cases of the system will be described here.

23.2.1.1. *Populating the reference database*

This scenario concerns the definition and insertion of the reference material of the European Parliament within the EDUCASE system.

1. The reference database is populated using the existing editing and data entry tools provided with the software.
2. A researcher identifies a number of documents, images, video clips and speeches, which cover the historical development of the Parliament.
3. All the inserted material is classified into course material, case studies and a set of learning goals/path is defined.
4. All the documents are digitised and converted to HTML and the images are converted to JPEG.

23.2.1.2. *Populating the dynamic database*

This scenario describes how a user can register into the system, insert data, create projects and set assignments.

1. The user accesses the Web server and get registered in. Each user receives a unique digital signature (like a credit CARD ID) that will be used to identify them in future.
2. Each registered user has a personal Web space and a personal profile where they can submit reports, research and personal details.
3. Students are grouped into classes. Classes are grouped into teacher groups. Teachers are grouped into schools. Schools are grouped into divisions etc. Each group of users has a Web page including all members' ID cards.
4. A teacher submits assignments for members of the class. Each pupil create a set of documents (or projects) for that assignment.

23.2.1.3. *Student assignment work*

This scenario describes a simple use of the system to define a collection of resources and publish it.

1. A teacher or a user organize the assignment work and/or the project work.
2. Students research for information in the reference EDUCASE database or directly on the Internet. They include and collate their contribution (results) into a report document.
3. Students use a dedicated HTML content editor to structure, format and organize their resources. They publish the document to the dynamic database.
4. Teachers receive a notification after each student contribution.

5. All the project or assignment work is structured into a document collection.

23.2.1.4. Inter School work

This use case describes a path of interaction and collaboration between users.

1. A head teacher or educationalist set up a user group composed by members of a different classes, different schools and perhaps different districts

2. The head user set up the access rights to the group project page.

3. Each member contributes to the project submitting their own contents.

23.2.1.5. Educationalist research

This scenarios outline how a researcher can analyse and monitor the progress and effectiveness of the system.

1. The logging system will contain information about chioce material and decisions made by students.

2. A educationalist has read access to all elements of the database and can view any assignment and report submitted across all users.

3. The educationalist calls up an analysis tool to produce a report of activity within a certain project or for acertain student.

23.2.1.6. Registering new schools

The last use case describe a possible way to expand the ParlEuNet system to other schools.

1. The ParlEuNet will be publicly visible, but no write or access will be possible to individual class work of students. Only school and class Web pages will be visible.

2. A new school may apply to be registered on the system. When agreed by the administrators, they can be included in the network.

3. The new school Web space will be automatically created when they register in the first time.

23.3. TECHNICAL DESCRIPTION

The following section will depict the system architecture as is under development at the JRC.

The ParlEuNet system will be built using a four tier layered architecture. A modern *Web browser* on the client side, a *Web server* on the server side backed by the *applications/tools* and the underlaying data holding. There will be a level of indirection into the data holding splitting up the database into two parts : the *entity object model* and the *flat data storage* (see Figure 2, next page).

The entity object model contains the links, references and metadata which constitute the virtual worlds which make up the users environments. Whereas the flat data storage contains the physical images, sound and video clips, the reference material (EDUCASE) and text files. The neat separation between logical and physical resources will allow to mirror part of the system on CD-ROM or onto a Web site close to the target schools (Intranet).

The actual model of the World Wide Web does not address issues like user identification, session management, persistence and data description. The ParlEuNet system will try to solve those problems using an enhanced Web server integrating modules to handle user identification, session tracking, user profile persistence and metadata handling. This implies that a complete personalized and persistent environment will be automatically available prior to invoking the ParlEuNet application components.

To identify uniquely a user on the system a digital certificate and/or a basic
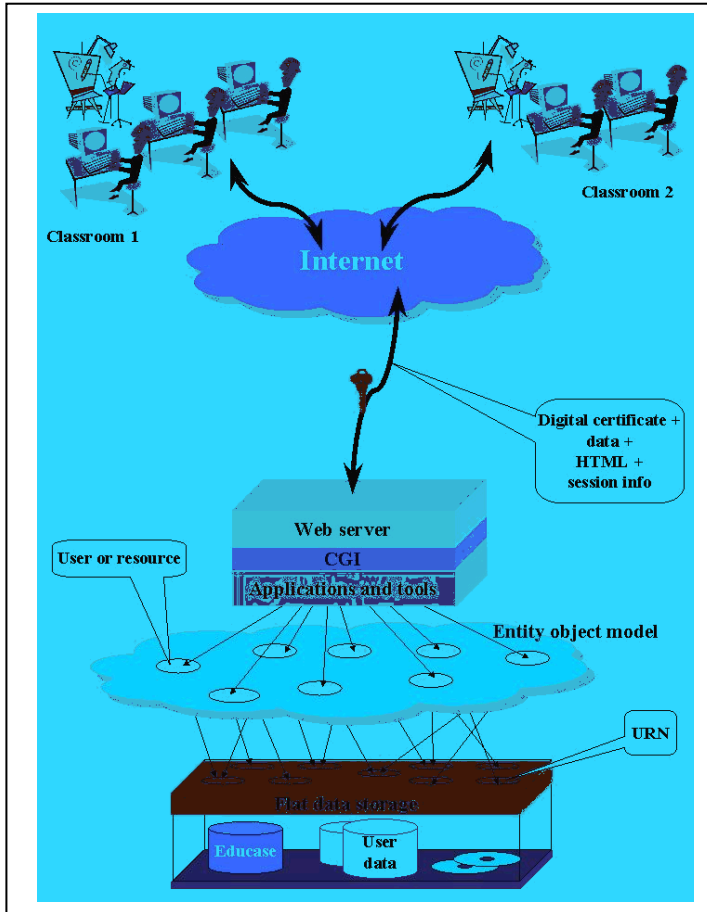
Figure 2 - The ParlEuNet system architecture

authentication will be used. This solution will be almost invisible to the user. A separate session module, built into the Web server will manage and track individual user sessions (i.e. a user having multiple sessions opened, or logged in on more than one machine). Using the identity, the authorisation and session information a private profile database, session database and Web accessible directory will be made available to the application being invoked.

The general architecture shown in Figure 2 emphasizes how the system has been defined according to application specificity. A rigorous distinction between User Interface (UI) components and applications, entity object model and flat data storage has been made. The reason for the fisrt distinction is to make functional decomposition easier and allow a fast prototyping of the user interaction. This functional separation will allow to deploy and store part of the server applications near the user Web browser and tighten the bandwidth requirements.

The distinction between the entity object model and the flat data storage is twofold. First, it allows references to the EDUCASE database directly from projects and assignments. Secondly, through a set of CD-ROM backups will be possible to move part of the physical entities on the client side (in particular those elements which are too

cumbersome to transfer or which are often used). In this way, users will be still able to modify elements referred to on the CD-ROM, but such a modification would imply that the data will be loaded from the remote data storage again until the next backup is burned and dispatched. Using the Uniform Resource Names (URN) technology will be possible to federate and independently manage these entities. A URN consists of a persistent URL with an extra level of indirection behind it. Federated URNs will allow for an arbitrary number of depositories with little or no interconnections or shared management. The URN resolution to a URL will be done automatically when necessary.

The entity object model contains effectively a object relation model of various resources owned by pupils, teachers and managers, such documents, projects and assignments. To communicate such information structure between client and server applications a metadata strategy is needed. This should allow to serialize the data model and pass it fore and back between the Web server and the Web browser. At the JRC, it is under investigation the use of the new Web metadata technologies like the Extensible Markup Language (XML) and the Resource Description Framework (RDF) to fulfill this crucial task.

23.4. SYSTEM PROTOTYPING

A series of prototypes of the PalrEuNet system are under development at the JRC. These aim to provide a basic framework on which will be built the final system.

The actual prototypes are implemented using Apache (version 1.2 or higher) as Web server running on a FreeBSD UNIX machine, PERL5 as programming language on the server side and HTML/Java/Javascript to provide the UI on the client side. The system has been tested using Netscape 3.0 and/or Netscape Communicator 4.0 as well as MS-IE 3.0-4.0. The Apache software has

been customized to include a session module, a digital certification module and many others.

The prototype is available at the following address :

https://mda05.jrc.it

23.5. WHAT TO EXPECT FROM THE PARLEUNET

A first prototype of the system should be ready by September 1998. Based on the first prototype the final system will be defined and implemented.

A variety of collaborative activities will be planned in the experimentation phase. ParlEuNet will experiment with pedagogical models that promote student-centred problem based learning aiming at the design of guidelines for working in telematics learning environments. Training workshops will be conducted to integrate the telematics learning environment into classroom practice, get feedback on content, the appropriateness of the media involved. Following the experimentation, the results will be analysed. In addition to educational publications, a practical guide will be produced to disseminate the results to other European schools to generalise the results from the pilot experiment. A hands-on workshop in the European Parliament will be organised for policymakers and Parliamentarians. Workshops will be organised on a national level by parents' associations as well as the distribution of a project video and major on-line hyperlinking with European educational projects.

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D. OPEN AND DISTANCE LEARNING AND COOPERATIVE WORK

INVITED PAPERS:

David Birchall, M. Smith, "*Open and distance Learning and Co-operative Work - A Case Example in Management Development*"

Peter Hicks, "*Computer Assisted Learning in Electronic Engineering Education*"

COMMUNICATIONS:

N. M. Costa, J. R. Galvão, "*CAPneTS a Computer aided pneumatics teaching system*"

A. J. Osório, "*The potential of telematics for the education and professional development of teachers*"

Diane Slaouti, "*Teachers teach; teachers program: lessons learnt in developing a distance course in educational technology*"

J. R. Galvão, M. R. Gomes, "*Evaluation of production and teaching by virtual environment*"

D. Birchall's invited paper, "*Open and distance Learning and Co-operative Work - A Case Example in Management Development*", uses as a case study the distance education MBA programs of Henley Management College (UK). Started in 1982 the history of the MBA provides very interesting material on the the use of information technology for distance education. The effectiveness of "collaborative learning" both as a means to achieve a deep level understanding and as a tool to foster collaborative work practices, is one of the important points that stands out.

P. Hicks in "*Computer Assisted Learning in Electronic Engineering Education*" reports on the development, delivery and use of the EDEC Multimedia courseware, the result of a large project financed by the the UK TLTP (Teaching and Learning Technology Program), that has had also contributions from a TEMPUS project, *coherence*. The paper analyses the data collected from the use of the coourseware, the main conclusion being that it should be used as an addition, not a replacement, of face-to-face teaching.

The communications of A. J. Osorio, "*The potential of telematics for the education and professional development of teachers*" and D. Slaouti, "*Teachers teach; teachers program: lessons learnt in developing a distance course in educational technology*", address the use of the new technologies in teacher's education. N. M. Costa, J. R. Galvão, "*CAPneTS a Computer aided pneumatics teaching system*" describes courseware developed by the authors, while J. R. Galvão, M. R. Gomes, in "*Evaluation of production and teaching by virtual environment*" provide an evaluation of the results.

online educa berlin 98
new technologies for higher
education

24. OPEN AND DISTANCE LEARNING AND CO-OPERATIVE WORK – A CASE EXAMPLE IN MANAGEMENT DEVELOPMENT
INVITED PAPER

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24.1. INTRODUCTION

Henley Management College has more than ten years experience of using computer-mediated communications for supporting distributed learners. The delivery model now adopted seeks to integrate the use of a range of approaches into an interactive learning environment in which appropriate use is made of technology to support learning. Increasing emphasis is being placed on developing the manager's skills in working in a networked environment, in particular in distributed teams.

In this paper the authors review experiences in developing group based learning and supporting this with technology. They identify both opportunities and limitations so as to stimulate debate of the issues.

24.2. DISTANCE EDUCATION

Distance education has been defined as the conveying of knowledge to learners who are separated from the tutor in time and/or location (Snell *et al,* 1987) and it can be seen as a means of breaking down traditional barriers to educational opportunity. The use of the term 'open learning' in relation to the delivery of learning materials to distributed learners is, however, not synonymous with distance education.

The term 'open' implies removal of barriers created through distance, time and specific design (Lewis 1986). Distance education, with open access enhanced through the use of technology, can be seen as a cost-effective means of achieving this. However, distance learning programmes have been criticised for being prescriptive in their goals, pace and activities; also for a pedagogic process driven through learner interaction with materials rather than through mediation by tutors. In addition, those materials are developed in an environment that is separate from the learners.

The education sector is faced with a declining traditional student population and an increasing demand for more open access to learning. In addition, funding pressures on education providers to increase student numbers whilst reducing costs are also impacting on provision for learners. The new, integrated and cost effective forms of telecommunications are seen as effective ways in which such technologies can be used to support increasing numbers of students on distance learning programmes.

24.3. OPEN LEARNING

Whilst the traditional model of distance teaching has been described as one in which the burden of instruction is transferred from teacher to institution and materials and is therefore considered to have a 'dissemination orientation', Snell *et al* argue that 'open learning' comprises more than merely increasing accessibility to instruction. They present open learning as a 'development orientation' which "emphasises the development of the whole person and their ability to construct meaning in and through their lives" (p 166). This definition of 'open learning' can be further widened by the extent to which the responsibility for learning is taken on by the learners themselves. In this wider definition open learning is referred to as *self-directed learning* (Brookfield, 1986) where learners plan, conduct and evaluate their own learning.

It is clear that there is an aspect of 'relativity' about the term 'open learning'. Lewis stresses the concept of a *continuum* of openness which is positioned through institutional preferences as well as tutor, programme content and learner preferences. Snell *et al* see a building process of openness, as the responsibility for direction, content and process of learning is passed from teacher to learner with the result that the learner moves from being directed to being self-directed.

24.4. COLLABORATIVE LEARNING

A third dimension to the debate on distance and open learning, has been the introduction of collaborative or co-operative learning. Collaborative learning is seen to take place when a group of learners, with shared goals and objectives, not only seek to progress their own learning but also take responsibility for the learning of other group members. The value of this pedagogic approach lies in it's association with a number of positive assumptions (Kaye,1991, MacConnell, 1994):

• that significant learning and deep-level understanding arises from a collaborative process and that a higher level of academic performance results from this

• that social and work-based benefits arise from the development of general problem-solving skills and strategies that peer collaboration supports

• that there is benefit from externalising one's own knowledge and understanding for the benefit of others and, especially in adult education, in the sharing of personal experience in support of the learning process.

Both Kaye and MacConnell identify open, student centred learning as complimentary to collaborative learning and recognise the value of computer mediated communication (CMC) to support such a learning process, especially the asynchronous systems.

In looking at the needs of the collaborative learner on an open learning programme, then, three key areas are identified: -

• access to resources in the form of information or content,

• access to tuition through lecture, tutorial, discussion or sometimes computer-aided learning tools,

• access to support, both academic, through teaching, facilitation or mentoring; through provision of appropriate additional information, confirmation of understanding, clarification etc., and through social support from peers.

These are mirrored in McConnell's perceived outcomes of the collaborative learning process and Brookfield's work which places a special emphasis on the social context of self-directed learning.

universe·if·turd. 98
new technologies for higher
education

24.5. CMC AND OPEN, DISTANCE LEARNING

Open learning at a distance, has been enabled through developments in technology - in the early stages through establishing cost-effective printing methods and an improving postal service. Latterly, the introduction of computer systems at increasingly advantageous power to cost ratios has been combined with the establishment of effective telecommunications networks linking computer systems at a national and international level.

The use of technology in open distance learning, and in particular of CMC, can be seen to have a 'push/pull' effect in relation to the changing patterns of learning. On the 'push' side, educational providers have identified CMC as an additional means of establishing economies of scale in relation to delivery of distance teaching programmes. Communication technology is also a means of 'un-distancing' the distance learner - in an increasingly competitive and customer orientated market, this enables educational providers to differentiate themselves through the nature of the 'virtual classrooms' they are able to present to potential 'clients'. The 'pull' of CMC originates in the changing nature of demand for educational provision. Learners are wanting to engage in educational opportunities appropriate in content, time and location, to their personal needs or needs established through their employment. To be able to engage in content-tailored learning experiences, when and where required, is becoming a 'customer' expectation.

24.6. USES AND TYPES OF CMC IN OPEN AND DISTANCE LEARNING

Educational institutions use technology in a variety of ways which Harasim *et al*, (1995) classify into three categories:

- *adjunct mode* where technology is used to supplement regular instruction,

- *mixed mode* where a regular element of the curriculum takes place through e-mail or computer conferencing and

- *online mode* in which all course activity takes place on line through a CMC system that structures content, discourse and activities.

Laurillard (1993), Paulsen (1995) and Bates (1995) are among those to describe the various technologies available to support both distance and open education and the ways in which they might be used. The different CMC systems each have distinctive features that impact on the manner and the extent to which they support the learning process. Paulsen, in his comprehensive report on CMC, summarises the three key differentiating factors as:-

1. The E-mail paradigm (one alone and one-to-one communication),
2. The bulletin board paradigm (one-to-many communication)
3. The conferencing paradigm (many-to-many techniques).

The one-to-one environments, prevalent in traditional distance learning programmes, can be seen as suitable for direct communication between peers or tutors/ counsellors/ administrators for the progression of individual learning. In the one-to-many electronic environments there are opportunities for the distribution of information, very much grounded in a classroom metaphor, but allowing for more student independent learning to occur. However, it is in the many-to-many environments, especially those within an asynchronous system, that the richness of open and collaborative learning becomes apparent; networked learning support, collective databases, community networking,

tutorials, discussions, group tasking, debate, peer counselling etc.

24.7. IMPLEMENTATION ISSUES

However, the difficulties of implementing such technology based learning environments need also to be acknowledged. Ease of access and skill development for new users provides motivation to overcome the 'learning curve' of unfamiliar technology. Turoff (1989) identified four stages of development through which users of CMC progress -

1. learning systems mechanics
2. learning how to communicate electronically
3. learning how to work electronically within a group
4. learning how to adapt and develop the CMC system to maximise utility

Learners can become locked at Stages 1 and 2 through lack of familiarity with the technology (Akehurst, 1996; Birchall and Smith {a}, 1997). Motivation to progress onwards will only come through the technology demonstrating that it can meet learner needs. Birchall & Smith found that learners placed a high value on the active participation of tutors. This raises the question of tutor input and facilitation skills. Again, lack of technical expertise, conflicting demands on time and, in some cases, a lack of imperative from Management results in academics facing personal tensions in this area (Birchall & Galpin, 1996).

Another area where there is a challenge to the successful implementation of technology to support learning is in the designing of the software itself. Of the five levels of learning identified by McDonald and colleagues (McDonald *et al*, 1976), designers of software for use in open and student centred

learning are focusing on moving students to the levels of global interactions or 'intuitive understanding' and constructive understanding where the learner 'creates' fields of knowledge. Somekh (1996) urges evaluation and feedback from commencement of courseware design onwards, to focus on whether or not, and to what extent, the software maximises such learning. This, in turn, raises a question on the choice of CMC technology - how far should it be bespoke or to what extent developers can adopt 'shrink-wrapped' or ready-made applications. The former is a costly and time consuming activity but can result in a fully tailored CMC system designed to meet the needs of specific users and tutors. However, the Teaching and Learning Technology Programme[#], which funded many such developments, has recognised the problems inherent in this approach; that applications lack a generic focus and that the 'not invented here' syndrome places barriers on dissemination to a wider audience. The use of commercially available systems is more cost effective and time economic but presents the instructional designer with questions as to what extent the programme of study should be modified to fit into the existing system.

The implementation issues for both learners and education providers, around the use of CMC to support self directed distance learning, can be summarised as follows (next page):

[#] UK's Higher Education Funding Council's Teaching and Learning Technology Programme has funded projects in phases since 1992. The third and final phase commences in 1998 with a requirement to develop both generic applications whilst paying special attention to evaluation and implementation. This follows an audit report of TLTP Phases 1 & 2, carried out by Coopers & Lybrand.
http://www.tltp.ac.uk/tltp/index.html

Issues for the learner	*Issues for the learning providers*
Access to equipment that can support the CMC system being used or where lack of access implies being disadvantaged	Whether to make use of CMC mandatory or not.
Adequate training and on-going support in overcoming technical difficulties	How far the organisation has technical infrastructure and resources to provide training and support.
Ease of use built into the design of CMC environment	Choice of 'bespoke' system or off the shelf and technical expertise to support and develop either.
Being comfortable with using technology as an integrated tool within the learning process.	The development of facilitation skills amongst academics
Being convinced that the CMC system 'adds value' to the learning process by meeting learner's needs.	Identifying an effective evaluation process

Table 1

24.8. A CASE EXAMPLE: INTRODUCING A COLLABORATIVE ORIENTATION INTO MANAGEMENT EDUCATION DISTANCE LEARNING

Henley Management College has been delivering a Distance Learning MBA since 1982. Initially the programme had a traditional 'dissemination orientation' with core course material provided in the form of printed workbooks and text books with additional material being available on audio and video tapes. Face to face workshops offered opportunities for interactivity and student centred learning. However, an additional resource, in the form of a bulletin board CMC system was introduced in 1988 as a means of enabling dialogue between tutors and learners, and between learners themselves, via a series of computer mediated conferences.

Building on this development, in 1994 the groupware product, Lotus Notes replaced the original CMC system. In addition to providing continuing support to remote learners, the asynchronous technology that Notes is based on enabled the College to develop more 'student-centred' approaches within its distance learning programme. These were initially developments within Lotus Notes that focused on establishing a community of learners amongst the remote users. In addition, the workflow processing strengths of Notes was built into applications that enabled students to benefit from more efficient learner support - ordering working papers on-line, submitting assignments electronically, booking workshops directly etc. A final area of focus has been in developing subject based environments which offer personal development to distance learners through additional course content combined with the opportunity for

dialogue with other learners and expert tutors.

As the use of Notes increased amongst course participants, there was a move to develop database environments specifically aimed at promoting student centred collaborative activity between distance learners. These took the form of information and discussion environments that directly supported group outputs such as presentations and assignments. The access controls on these applications enable group members to collaborate in a private area as well as to 'invite' expert participation as required.

By the end of 1996, 2500 learner's worldwide were registered on the system. However, use varies considerably, from the small proportion of highly active users, a high proportion of 'lurkers' (non-participant observers) and many non-users, much in line with evidence from elsewhere (see for example Mason, 1995). Course designers saw one of the main reasons for this low utilisation as the lack of integration into the total learning experience. A decision to move to the electronic delivery of a much more significant part of the programme led to a rethink of how to integrate the various media.

In designing a new programme module to be delivered principally on CD-ROM the opportunity was taken to review the needs of learners, the programme objectives and the means for delivery. Largely for cost reasons a decision had been taken to explore how best to deliver courseware on CD-ROM but this did make possible a more comprehensive rethink. Whilst it was recognised that many learners would not have access to CD-ROM players, it was felt that many would want to equip themselves with the appropriate technology or would be able to gain access through their employers.

It is seen as increasingly important that managers of the future should be equipped to take advantage of the emerging digital technologies and that they should be introduced to new ways of working at the outset of their study with Henley. This new approach to programme delivery and support was intended not only to convey programme subject matter, but equally importantly it was to get learners used to exploring new ways of working and studying. Rather than the delivery of static information it was intended to introduce the learner to the more dynamic world of information and knowledge made possible through Information and Communications Technology (I&CT) and the WWW. It was also intended to introduce them to team-based collaborative learning using the medium of electronic Groupware, thus offering the opportunity to develop a range of skills seen to be of crucial importance in the workplace of the future. The learning materials based on CD-ROM now offer a more dynamic and integrated learning environment through the inclusion of seamless links to specific activities within the Henley Notes community, as well as into relevant areas on the WWW. Learners can supplement their learning materials from either source as well as extending the learning experience into a collaborative process through joining discussion and debate on the issues being progressed.

Embedded within this approach was the objective of moving learners from the 'discovery' paradigm towards an 'exploratory' paradigm (see MacFarlane, 1995 for a detailed explanation of the basic paradigms). It also helped to make them recognise the need to take personal responsibility for their own learning and to give them initial stepping stones to achieving this. The work of MacDonald *et al* (1976) provide a five scale typology of levels of learning via computer assisted learning. These can be summarised as

A) recognition [text dependent],

B) recall [text dependent],

C) reconstructive understanding or comprehension [text independent but discourse dependent],

D) global reconstructive or 'intuitive' understanding [experiential learning, discourse independent] and

E) constructive understanding.

In the development of the learning experience we seek to move learners through the five levels to achieve constructive understanding but assume that this will only be achieved if we can create a rich learning environment which proves stimulating to learners. For this to be the case the learning has to be seen as legitimate by the learner, in that it must have a connection with, and relevance to, the management of their businesses within the wider political, social and economic framework in which they operate.

The design of the CD-ROM based materials was also influenced by earlier experiences of courseware development for delivery electronically. There were two important features of the earlier experimentation, which were adopted in this development. Firstly, the opportunity for learners to progressively build up their assignments for later submission for assessment as they progressed through the study (in the text based form the assignment is normally worked on following completion of the study material). Secondly, to move the emphasis away from elaborate graphics which users felt did not aid the learning process but rather reflected the courseware designers interest in exploring the capability of the technology. Additionally, evaluation of existing courseware has been an essential part of moving our own understanding forward. Programmes such as the UK Higher Education Councils funded TLTP (Teaching and Technology Learning Programme) and the CTI (Computers in Teaching Initiative) are both rich sources of educational software made relatively freely available to educational establishments.

In reviewing these experiences we are particularly mindful of Somekh's (1996) appeal to focus software evaluation on the products' capacity to maximise learning; what she later refers to as 'constructive' learning that results in the learner internalising a concept. This stands in contrast to "early software of the drill and practice kind...designed according to Skinnerian principles" (p.5). In consequence we have been attempting to learn from this experience and develop an approach which meets our own particular needs. These are defined by the context in which we operate, our own capabilities, our learner needs and preferences, the financial constraints and those imposed by the technology at this stage in its development.

24.9. FINAL THOUGHTS

There is an overlap in the use of terms such as 'distance teaching/learning', 'open learning' and 'self-directed learning'. On balance the view of *distance teaching* is of a delivery route for programme content which is seen to have a significant element of *open accessibility* in the sense that learners are able, within varying degrees, to access learning in their own time from a location of their choosing. However, *open learning* is identified as having a development orientation that can be espoused in any learning environment from face-to-face to that undertaken at a distance. In addition open learning is seen to be on a continuum moving from tutor directed/learner negotiated activity towards learner-centred learning in which the roles of tutor and learner become interchangeable.

An integrated learning environment has been shown to appropriately support open learning at a distance, especially collaborative group learning, through a combination of direct links between content delivery and the discussion and information

environments that can be established. However, questions remain about the degree to which access to technology itself closes down rather than opens up the learning experience. From research done earlier amongst Lotus Notes users (Birchall & Smith,{a} 1997) 96 items were cited as creating difficulties for the users and these can be divided into three categories:-

1. Personal responsibility - inadequate

modems, forgetting password, unable to find unread messages.

2. Software design considerations - not intuitive enough with difficulties in mastering the replication process predominating.

3. Cost - many, however, recover costs from an employer so it would not be a major concern.

Needs of the self-directed collaborative learner	*Features within a integrative learning environment*
Delivery of some programme 'content'	Through CD-ROM interactive resource
Supports the planning of own learning or the learning within a group	Access to asynchronous CMC environment
Enables information to be stored, structured and shared	A Lotus Notes learning resource environment allows not only for the collection of information, including hyperlinks to the WWW, but also allows others to comment on contributions. In addition, the provision of a range of analysis tools in the form of pro-formas supports the relating of the information to a more focused activity.
Can incorporate different levels of access allowing groups to collaborate in closed areas but at the same time giving access to wider discussions.	The Lotus Notes environment provides access controls allowing groups to operate within discrete environments
Available at time and place of own choosing and at self determined pace	Lotus Notes is used as client software through asynchronous access to the central server. The CD-ROM material stands alone to be accessed as required and the WWW is always available.
Provides opportunities to engage in debate with peers and tutors	For learners there are many Notes facilities designed to support discussion with nominated parties- tutors, 'experts', practitioners etc. either in the group secure areas or in an open discussion environment as well
Provides for review and reflection on learning	The Notes based discussions provide one area for learning to be reflected upon in a fairly open and unstructured way. Some databases additionally provide a 'Learning Journal' facility which is private between an individual learner and a nominated tutor.

Fig 1. A summary of what are seen as the key needs of the self-directed learner and how they can be met within an integrated learning environment.

These results suggest that, with technical aspects proving to be a barrier, we have failed to progress the users mastery of the technology and the means to achieving this, especially amongst distance learners, is challenging. Clearly some difficulties result from lack of user ability. In addition there are aspects of the system which also create problems. However, the perseverance of managers in learning to use the technology is unlikely to be high if their main concern is the achievement of an MBA unless they perceive these skills as essential to success in their subsequent career.

The growth of collaborative learning and its facilitation via CMC encompasses some complex questions, which requires more research in order to inform our progression towards more effective user environments. The extent to which users are able to develop skills beyond being able to communicate electronically is unclear. It does appear, however, that the potential of Lotus Notes, as a tool to support collaborative team working, is not being fully utilised. There are issues around the barriers that technology itself imposes on the non-technoliterate user. How to provide both ongoing skill development at a distance as well as optimising the design of the user interface to make it fully supportive remains a challenge.

However the level of learner participation in part reflects the level of tutor involvement in system development and course delivery. Faculty are having to move up the same learning curve as the students. In addition they are having to develop skills in pedagogic design and electronic delivery suited to a new system. Given conflicting demands on their time this is creating personal tensions (see Birchall & Galpin for more detail). Not only does this require a review of the role of the tutor but there needs to be research focused on identifying the nature of the learning facilitation task and how to most effectively undertake it.

As an institution we are very aware of the need to establish a sound methodology on which to base formative evaluation of the learning technologies we develop. Much work has been done in this area (e.g. Mason(1991), Connolly(1988), Somekh(1997), McKenna(1995), Oliver & Conole(1998)). However the seductive quality of the technology itself tends to cause it to be put above any process of evaluation. In addition, for those developing learning technologies the developmental time-scales are all too often too short to allow for the inclusion of effective evaluation. However, technology is not to become the tail that wags the educational dog then evaluation must be central to the developmental process and a better understanding of how this can be achieved needs to be researched.

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25. COMPUTER-ASSISTED LEARNING IN ELECTRONIC ENGINEERING EDUCATION
INVITED PAPER

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Abstract **- The innovative exploitation of Communication and Information Technologies (C&IT) promises to improve the quality, flexibility and effectiveness of engineering education. However, we must first understand how to integrate new-technology based media with existing teaching methods and the impact that this will have on student learning. EDEC, a consortium of electronic engineering departments from eight universities in the UK, has developed over 150 hours of computer-based learning material to support the teaching of analogue and digital circuit design. This paper gives details of the £1M project that led to the creation of this material and some of the experiences of users who have been using the courseware with their student classes.**

25.1. BACKGROUND

Almost since the birth of the computer attempts have been made to find ways of harnessing this technology to support the teaching and learning process. Early attempts were hampered by technological limitations and it is only with the comparatively recent development of user-friendly graphical user interfaces (GUI) and the introduction of multimedia PCs that the true promise of computer-assisted learning (CAL) is starting to be realised. The important role that computers can play in teaching and learning has been officially recognised for a number of years. In 1983 the UK Computer Board commissioned a review of computing facilities for teaching in universities which led to the publication of the Nelson Report [1]. One of the fundamental recommendations of this study was the setting of a target of one computer workstation per five undergraduate students by 1990. Another survey of the provision of computing facilities for teaching was carried out by the Inter-University Committee on Computing (IUCC) in 1991. This reached the disturbing conclusion that out of 44 institutions which responded to the survey, over half (25) had failed even to achieve a 1:10 ratio - that is half way to the Nelson target set for 1990 - while only three institutions had actually met or exceeded the target [2]. These days Higher Education (HE) institutions in the UK are still struggling to achieve the 1:5 target due mainly to cut-backs in government funding, although shifting priorities mean that adequate levels of provision are now starting to be achieved.

A beneficial outcome of the Nelson report was the launching of the Computers in Teaching Initiative (CTI) in 1985 with funding provided by the Computer Board and the University Grants Committee (UGC). The CTI's aims are to:

- evaluate the educational potential of IT in university teaching
- raise the level of awareness of IT among academics and students

- promote the development of computer-mediated training and learning

Over a hundred projects were funded during the period 1985-89 and a second phase saw the establishment of some twenty CTI Centres around the country, each of which was focused on a specific discipline [3]. The CTI Centres have been charged with the task of 'enhancing the quality of learning and increasing the effectiveness of teaching in all subjects within the UK university sector through the application of information technology'. They accomplish this by publishing newsletters and directories containing information on educationally-useful software in specific disciplines and running activities such as courses and workshops.

The CTI Centres are now funded by the Higher Education Funding Councils of England Scotland, Wales and Northern Ireland and during the 1990s these bodies launched a number of other IT initiatives aimed at improving the quality and efficiency of teaching and learning in the UK university sector. The first of these was the Information Technology Training Initiative (ITTI) which commenced in 1990 and aimed to improve the availability of IT training materials to assist computer centres in dealing with their IT support role [4]. The second and by far the most significant is the Teaching and Learning Technology Programme (TLTP) and this is described in more detail in the following section. A third initiative, the Fund for the Development of Teaching and Learning (FDTL), was established in 1996 to support projects aimed at stimulating developments in teaching and learning in higher education and to encourage the dissemination of good practice across the sector [5]. Applications for funding under this programme can be made only by those subject providers that have

demonstrated, through quality assessment, high quality in their educational provision. The funding councils have committed £8M to fund 44 projects under the FDTL programme over the two years 1996-97 and 1997-98.

25.2. THE TEACHING AND LEARNING TECHNOLOGY PROGRAMME

The declared aim of the Teaching and Learning Technology Programme [6] is to make teaching and learning more productive and efficient by harnessing modern technology. The programme was launched in 1992 with the announcement of 43 projects having a total value of £22.5M over three years. A second phase of TLTP funding was announced in 1993 to support a further 33 projects at an estimated annual cost of around £3.75M.

The Phase 2 TLTP projects were also funded for three years bringing the total cost of the programme to somewhere in the region of £33M. To this must be added the cost of academic staff time that has been committed to the projects, and experience has shown this to be a very major contribution to the overall total. A realistic estimate of the total investment in educational technology that the TLTP programme represents to date is therefore in the region of £70M to £80M. The launch of the third phase of TLTP has recently been announced in which the Higher Education Funding Council for England (HEFCE) intends to spend a further £10.5M over the next three years on projects aimed at the implementation of courses using educational technology.

Approximately one quarter of the first round of TLTP projects addressed problems of implementation within single institutions, with staff development a major component of several of these. Most of the remainder

edmedia/ed-telecom 98
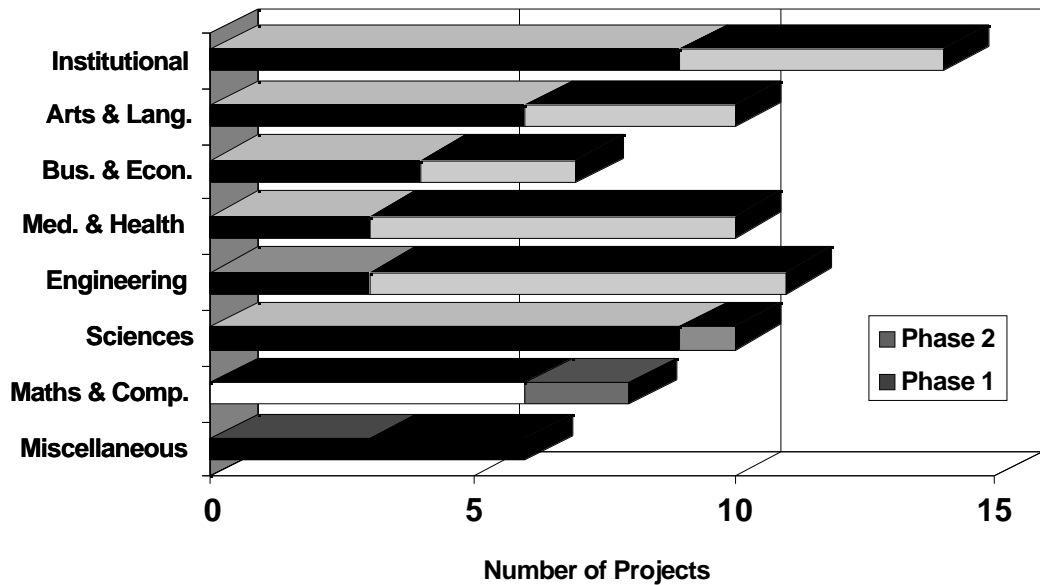new technologies for higher
education

Figure 1. Distribution of TLTP projects by discipline

were concerned with courseware development and involved academics from several institutions. These multi-institution consortia have formed the backbone of TLTP with sizes ranging from 2 to 44 institutional members. The distribution of TLTP projects according to subject area is shown in Fig. 1. Here it can be seen that 11 of the projects directly address engineering disciplines while a further 18 are in the related fields of mathematics, computing and the sciences. Many of the TLTP projects use commercially-available authoring tools such as Authorware Professional and Toolbook for the production of their courseware. These tools appear to be particularly popular with the science and engineering communities, possibly because they make it relatively easy to incorporate animated graphics into the courseware. It is worth noting here that the TLTP programme more or less coincided with the birth of the World Wide Web, although few projects recognised the enormous potential of the WWW in teaching and learning in those very early days.

The normal pattern is for courseware content to be defined initially by academics, although thereafter the consortia have adopted a variety of different implementation strategies. Some consortia have used the services of dedicated Computer-Based Learning Units located within their member institutions whilst others employed teams of Research Assistants. In one or two cases the task of implementation was sub-contracted to commercial organisations specialising in the production of computer-based training materials.

25.3. EDEC - THE ELECTRONIC DESIGN EDUCATION CONSORTIUM

The aim of the EDEC project is to develop computer-based learning material to support the education of Electronic Engineers and Computer Scientists in the design of electronic circuits and systems.

For more than ten years electronic engineering in the UK Higher Education sector benefited from access to high-quality electronic computer-aided design (ECAD) software provided through a national scheme called the ECAD Initiative. This had around 100 members including universities, research establishments and Colleges of Further Education. In 1989 a similar European-wide initiative (formerly EUROCHIP, now EUROPRACTICE) was set up specifically to promote VLSI design education. Access to ECAD software is essential for a modern electronics education. Electronics design, production and manufacture relies universally on computer-based processes from the instant of design conception, through the many different implementation styles, to final testing. All students of electronics must gain practical experience of the methods and techniques embodied in these tools by carrying out design exercises similar to those undertaken on a larger scale in industry. However, the software is often extremely complex and the close supervision and support of students using these tools has proved to be very staff-intensive.

Computer-Assisted Learning (CAL) has the potential to enhance the student learning experience without necessarily increasing the teaching load on staff. This is the rationale that lay behind the decision to launch the EDEC project as an investigation into the role that CAL might play in the education of electronic engineers. The EDEC consortium was formed under Phase 1 of TLTP to undertake the development of courseware which enhances the educational value of ECAD tools and helps to reduce the amount of staff effort needed to teach electronics design. The members of the consortium are the Universities of Bristol, Essex, Huddersfield, Kent, Manchester and Newcastle, the University of Manchester Institute of Science and Technology (UMIST), Oxford Brookes University and the Institution of Electrical Engineers (IEE). Over twenty academic staff and sixteen full-time Research Assistants were engaged in developing the courseware with a total budget approaching £1million.

25.3.1. *EDEC Courseware Themes*

The EDEC courseware is sub-divided into four major themes. These are:

1. Electronic Circuit Design
2. Digital Design
3. System and High Level Design
4. Testing and Design for Test

The first two each contain approximately 40 - 50 hours of material and cover a substantial proportion of the syllabuses for core courses in electronic circuits and digital logic design at first and second year undergraduate level. The System and Test themes each comprise 30 - 40 hours of material and are aimed at a somewhat more advanced level in the curriculum - typically third or fourth year undergraduate or possibly even postgraduate (MSc) level. More detailed information including module descriptions and demonstration samples from each of the four themes can be obtained from the EDEC WWW site [7].

25.3.2. *The EDEC Shell*

A standard shell has been developed for the EDEC courseware to provide a common framework with a uniform method of navigation and screen layout. A feature of the EDEC shell is the flexibility that it provides for the customisation of modules to suit individual user requirements. This is accomplished by means of a module configuration file which can be easily modified by the tutor to determine the order in which chapters or sections are presented, and even decide on whether certain components should be left out altogether. Additional user-supplied material may also

be integrated into the courseware, where necessary, using so-called 'media links'. This material could be a text file or a video clip, for example. The media links file consists of a description of the link, the name of the program used to display the information, the name of the file which the information is in and a list of pages to which the link is relevant.

The layout of the screen itself consists of two parts; the main area where the course material is to be displayed, and a panel of control buttons and a status message. The shell has been evaluated by groups of students to test the user interface and a number of iterations have been made to the navigation tools to arrive at a system which has all the required functionality and is also easy to use. Example screenshots showing the layout of the screen and the button bar controls can be seen in Figs. 2 and 3.

Authorware Professional has been adopted by the Consortium as the standard tool for courseware development and early versions of the shell were constructed using Authorware. However, problems were experienced with the sluggish response of the Authorware shell to user commands, even on relatively powerful PCs. For this reason the shell was re-written in 'C' to produce a Dynamic Link Library (DLL) which can be linked to the courseware modules. Theme 'C' initially chose to use a fourth generation programming language, Knowledge Pro for Windows (KP-WIN), as its preferred development environment although it has subsequently been decided that this material should also be transferred to Authorware.

25.3.3. *Courseware Development*

Anyone contemplating the development of courseware, or the use of such material with their students, would be well advised to first read Diana Laurillard's book "Rethinking University Teaching - a framework for the effective use of educational technology" [8]. Based on years of research into *how* students learn and using data gleaned from her own experience in the British Open University and elsewhere, Laurillard's treatise is a serious attempt to define those elements that are necessary to build a successful learning framework. The analysis leads to the construction of a 'conversational framework' which identifies all of the activities that are necessary to complete the learning process. Computer-based tutorial material (courseware) and simulations both have important roles to play in this process, although it is interesting to note from the results of Laurillard's work that they are not in themselves sufficient to address all aspects of the conversational framework.

The EDEC material has been designed for use in self-study mode and each module provides self-contained coverage of a particular topic. In choosing the topics to be included in the courseware some thought has been given to areas that can benefit from a computer-based learning approach. Consultation has taken place with potential users to determine the content of the courseware developed for each of the four EDEC Theme Groups. A formal procedure has been devised to guide the courseware development process and this involves clearly identifying the learning objectives before working out how they can best be achieved [9]. Interaction is a key ingredient of successful courseware because it helps to engage the student's interest and this principle has therefore been embodied in the material produced by the Consortium. Extensive use has been made of animation to illustrate dynamic processes and sound and video have also been employed although to a lesser extent. Students are frequently invited to answer questions on the material they have been studying to provide feedback on their rate of progress.

There is insufficient space here to describe the scope and content of the courseware in detail, and the reader is referred instead to the EDEC entry in the TLTP Courseware Catalogue [10] or the EDEC World Wide Web pages which can be accessed via the Internet [7]. To give some idea of the sort of material that the Consortium has produced it is perhaps worth mentioning just a few examples of module content.

In the Digital Design theme students are introduced to the basic ideas of Boolean logic, number systems and combinational and sequential logic design through a series of modules that enable them to interactively explore these topics. For example, Fig. 2 shows a screenshot from the Number Systems module which uses a weighing machine analogy to explain the principles of

binary-to-decimal conversion. A number of the modules in the Electronic Circuits theme make use of a simulated 'electronic breadboard' on which simple circuits can be built and tested. Thus in one example an operational amplifier (op amp) is connected to a variable power supply and a signal generator is used to supply waveforms of varying frequency and amplitude to the input of the device.

To introduce an element of realism into the simulation, students find that they must click with the mouse on the on/off switches on the power supply and signal generator in order to switch them on. The op amp's input and output waveforms can be inspected using a simulated oscilloscope which employs animation techniques to create the illusion of a real instrument. This arrangement can be

Figure 2. Screenshot from the Digital Design Module "Number Systems"

used to illustrate many of the basic properties of op amps, for example dependence of closed-loop gain on feedback resistor values, clipping behaviour and so on. Another of the modules from the Electronic Circuits theme provides students with a design exercise to test their knowledge of instrumentation amplifiers, and a screenshot from this module can be seen in Fig. 3.

The exercise is presented in the form of a case study involving the use of strain gauges in a weighbridge which forms part of a system designed to prevent heavy vehicles from using a rickety old bridge across a river. If the student successfully completes the design a heavy truck is warned not to try to cross the bridge. On the other hand an erroneous design leads to the collapse of the bridge and the truck ends up in the river!

Animation is used in a variety of different ways in the Digital Design theme, for example to illustrate the dynamic switching behaviour of logic gates and flip-flops. In another module the differences between analogue and digital control systems are neatly portrayed using animations of the rudder on a ship or the sequence of steps involved in releasing a satellite from the hold of the Space Shuttle. Animation is used extensively in the System and High Level Design theme as well, in this case to show the data flow and state sequencing associated with graphs representing different architectures.

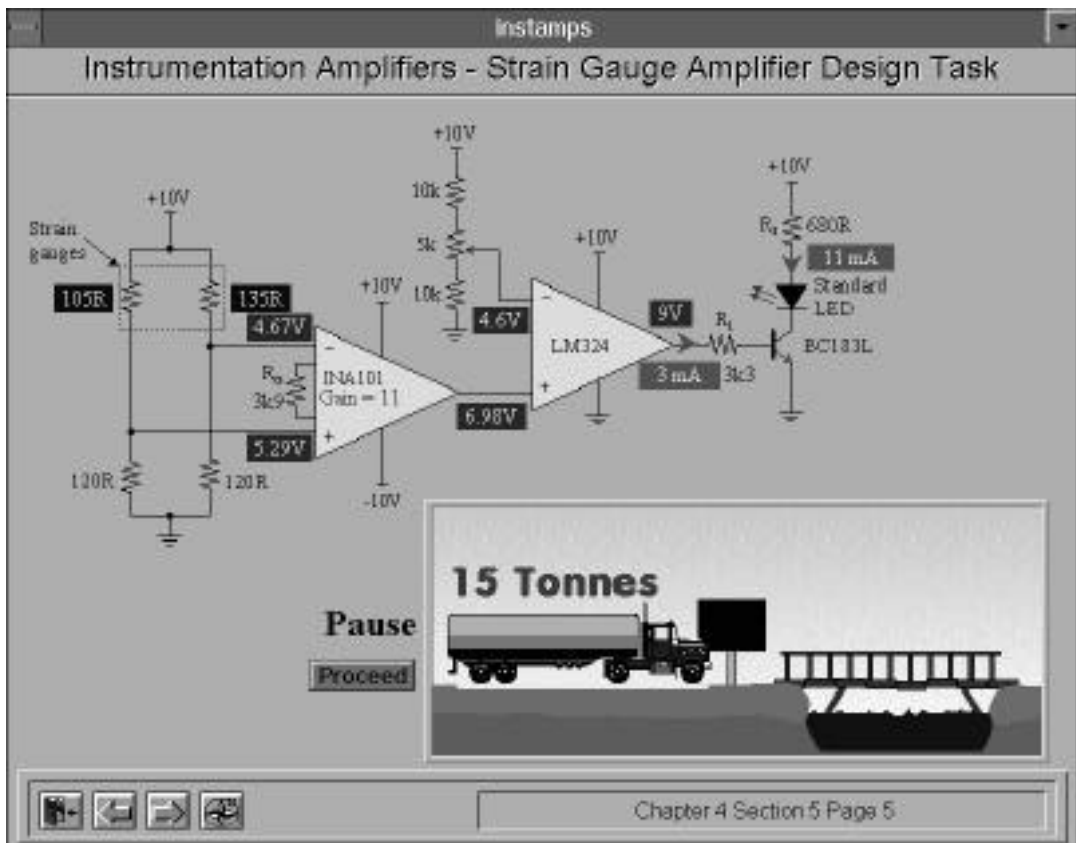Reports on progress are presented regularly

Figure 3. Screenshot from the Electronic Circuits Module "Instrumentation Amplifiers"

at meetings of the ECAD Educational User Group (EEUG) which attracts users of electronics CAD tools from nearly one hundred higher education institutions in the UK. These CAD users are also the potential users of the EDEC courseware and this forum, therefore, provides an extremely useful source of feedback which can be used to guide the development process. With such a large community of users already using ECAD software, the Consortium is in an excellent position to disseminate the courseware it produces and obtain a sound, independent evaluation of the results. The IEE, through its involvement in the consortium, is able to assist with the evaluation of the courseware and also assess its potential for use in other spheres such as distance learning courses and continuing education.

25.3.4. *Courseware Evaluation*

During the development process the courseware was subjected to several stages of formative evaluation. The first of these stages were conducted within the consortium whereas the latter stages were used to solicit the views of the wider user community. Feedback from the evaluation process enabled the development teams to modify the modules in response to comments from staff and students.

25.3.5. *Courseware Distribution and Delivery Platforms*

Altogether some 160 hours of computer based learning material has been produced by the EDEC partners and a full installation consumes around 200MB of hard disk space. Two methods are currently being employed for distribution of the courseware; electronic file transfer via the World Wide Web (WWW) and CD-ROM. Registered EDEC users can visit the EDEC web site [7] and select the modules they wish to download onto their machine. If required the software

can be automatically installed onto the user's machine once it has been downloaded. This web-based system has a built-in access control mechanism (only registered users equipped with EDEC usernames and passwords are able to activate the downloading) and also provides a continuous audit of module take-up. The CD-ROM is supplied with the choice of either running the modules directly from the CD or carrying out a full installation onto the system's hard disk; the former option requires around 20MB of disk space whereas the latter needs more like 200MB.

All higher education institutions in the UK are entitled to a free licence to use the EDEC software, although software maintenance and a regular update service are only available to EDEC subscribers at a cost of £500 per annum. Educational institutions in other countries can purchase a site licence for the courseware from EDEC Multimedia Ltd. for £2,000 and also subscribe to the maintenance and update service if they so wish.

Over the last four years a group of five Polish Technical Universities have collaborated on the development of a further 40 hours of interactive courseware covering parts of the following subject areas:

1. Computer Architecture
2. Introductory VHDL
3. Neural Networks
4. Image Processing
5. Graphics
6. Computer Networking
7. Reliability and Fault Tolerance

This project was funded under the EU TEMPUS programme and managed by Professor Erik Dagless at the University of Bristol. The courseware is again written in Authorware Professional and makes use of the standard EDEC navigation framework or shell. This software is now complete and is

being distributed to universities in Poland and to EDEC users in the UK for the final stages of evaluation.

The EDEC courseware runs under Windows 3.x and Windows '95 on IBM PC compatibles. The majority of the software has also been tested for compliance with Windows NT v4.0 and it is expected that the next major EDEC release (EDEC v4.0, due out in December) will be fully compatible with this operating system. The minimum configuration required to run the EDEC software is a 33MHz 486 PC running Windows 3.x with 8MB of memory. If the CD-ROM based version of EDEC is installed the disk space requirement is under 20MB, but if a full installation of all the EDEC modules onto the system hard disk is carried out then 200MB of disk space is needed. The software expects the system to be equipped with an SVGA graphics display capable of displaying 800 x 600 pixels and 256 colours. A CD-ROM drive is, of course, essential for the CD-based installation, and some of the modules expect a Soundblaster compatible sound card to be fitted.

25.4. USER EXPERIENCES

The EDEC courseware was first released in March 1996 and copies have so far been distributed to some 100 higher education institutions, mostly in the UK. Academics in many electronics departments around the country are currently investigating ways of integrating the EDEC software into their courses, and some data is beginning to emerge which describes user experiences in this area. The University of Newcastle-Upon-Tyne and Oxford Brookes University, both partners in the EDEC project, have independently constructed a number of new courses based on the use of EDEC material as a self-study learning aid. In these case studies the courseware has been used to

partially replace lectures and/or laboratory sessions, although other teaching and learning methods (lectures, tutorials, laboratories etc.) are still being employed to some extent as well. Students were invited to comment on their impressions of using the material and to compare the new technology approach with more traditional methods such as lectures and laboratory sessions.

At Newcastle [11] a first year course on Computer Engineering has been restructured to use computer based learning material in place of lectures. Whereas previously this course consisted of some 13 hours of lectures and 12 hours in the laboratory, the students now receive only 4 hours of lectures and use 6 hours of EDEC CBL material to cover the syllabus content. A series of tests were carried out in which the examination performance of students using the courseware was compared with that of control groups taught in traditional lectures. Their findings clearly suggest that carefully-designed courseware can lead to a large reduction in teaching time, with no significant difference in learning.

Trials of the software in the teaching of electronics at Oxford Brookes University [12] have revealed some interesting student reactions. The students used a representative sample of EDEC courseware modules on Semiconductors and the pn junction, Instrumentation Amplifiers and Automatic Test Pattern Generation (ATPG) to replace lectures on these subjects, and were then invited to give their opinions on the use of courseware as an alternative to conventional teaching methods. Asked if they agreed with the statement "I would prefer to learn from CBL rather than from lectures" only 36% of the students surveyed said they shared this view while 41% disagreed and 24% remained indifferent to the proposition.

It is interesting to note that the percentage disagreeing was higher for the Instrumentation Amplifier module than it was for the one on ATPG (figure 4.). A possible explanation for this may lie in the nature of the work that students were asked to do. The Instrumentation Amplifier module engages the student in a design exercise which tests their understanding of the principles involved to the extent that any deficiencies in knowledge will lead sooner or later to the need for support from a tutor. This underlines the continuing need for tutor support when courseware is used - in fact if anything the need for this may be increased as the students find their understanding of the subject being constantly challenged as they work through the material. Some 70% of students thought that CBL should be used in addition to lectures and practicals with the remainder divided as to whether it could be use to replace some lectures or practicals, or both. An overwhelming majority of 96% thought that the courseware would be useful as an aid

to revision for examinations.

The conclusions of this study were that courseware should not replace all face-to-face teaching, although there is clearly scope for some move in this direction (a figure of 25% replacement has been suggested). There is support for the view that multimedia technology presents a major opportunity for enhancing the student learning experience, although it is likely that some incentive will be required to motivate students towards self-learning. The material has proved to be popular with academic staff as a lecture aid, and this raises the issue of equipping lecture rooms with suitable projection facilities. Indeed, there are other important hardware issues to be considered as well, such as the provision of adequately specified PCs in sufficient numbers to cope with demand, and 24 hour access.
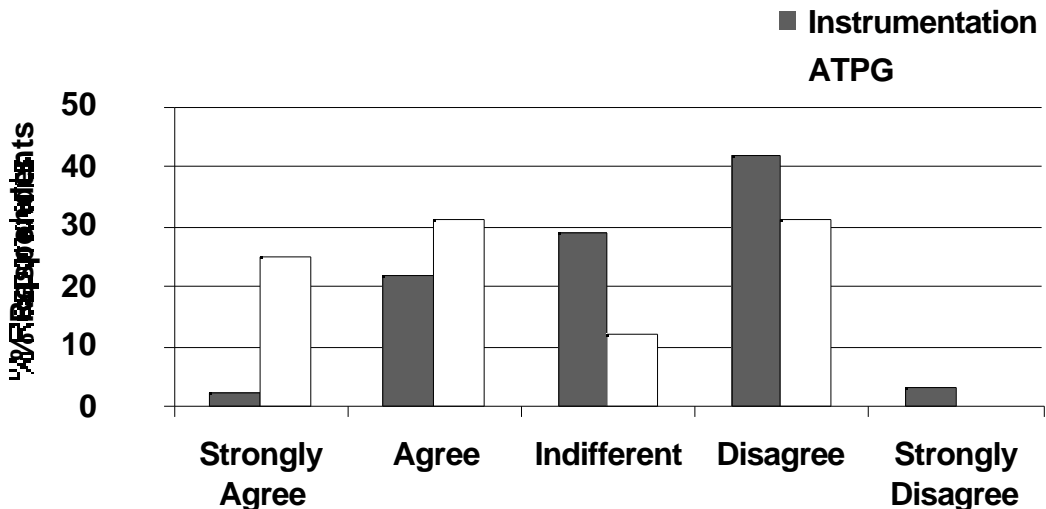

Figure 4. Student Responses to the Proposition *"I would prefer to learn from CBL rather than from lectures."*. (Data courtesy of Oxford Brookes University)

25.5. FUTURE DEVELOPMENTS

It was mentioned earlier that the third phase of the TLTP programme has recently been announced. EDEC bid successfully under this latest round for funding to integrate educational technology into a range of first and second year modules at undergraduate degree level. The aim of this project is to produce a number of exemplars of course units in the subject areas already covered by the EDEC material. The specific objectives are:

• To produce four new course units in the fields of electronic engineering and digital systems design which fully exploit the potential of teaching and learning technology.

• To adapt and use existing software programs, including the range of courseware modules already developed by EDEC, so that they can be launched from within a web-based delivery framework.

• To evaluate the educational effectiveness of the new courses, and carry out a cost-benefit analysis.

• To disseminate the results of the project both within the electronic engineering community and to the HE sector at large.

25.6. CONCLUSIONS

The Teaching and Learning Technology Programme succeeded in significantly raising the level of awareness of what educational technology has to offer in higher education and has resulted in the production of some excellent material. The EDEC consortium produced over 150 hours of interactive computer based learning material to support the education of electronic engineers and computer scientists and this has been distributed widely to universities and colleges throughout the UK. Only time will tell whether courseware similar to that generated by TLTP will achieve the anticipated gains in productivity and efficiency, although early indications are that both staff and students are receptive to this new medium and that it has the potential to significantly enhance the student learning experience.

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26. CAPNeTS - Computer Aided Pneumatics Teaching System

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Abstract **- Through the techniques of Multimedia and Virtual Reality environments, the animation of 3D geometric models and its display have been achieved, being created a computer aided teaching application designated CAPneTS, to the teaching of pneumatic models.**

The interaction between the user and the various sorts of information, about pneumatic components, which are available in database, is achieved by accessing to menus.

This application is expected to be a means of assisting the training and maintenance of this equipment, as well as a means of proportioning an assimilation of knowledge, through the animated functioning display of the present components, in various pneumatic circuits.

There is also a module that evaluates the knowledge about the operating principles of these devices and about its multiple ways of being connected among them, to succeed in a good functioning of the pneumatically scheme in the task to be performed. The trainee has also at his disposal, a module that helps the user, leads him to a complete comprehension and identification of the various sorts of the present elements.

26.1. Introduction

The introduction of environments supported by Multimedia and Virtual Reality technologies, may have advantageous aspects in the optimization of some productive sectors, in the diagnosis and in the overcome of possible malfunctions. It may also have advantageous aspects in teaching activities and, in the maintenance of pneumatic devices. On account of its graphical capacities, facility of interaction towards the user and, the easiness in obtaining all the information yet to be consulted, by turning to image, text, sound and animation, it is possible to achieve higher up-time in the productive process, when actions of maintenance are created. It is also possible to increase the reliance on the whole productive process, by means of a better knowledge of its components and its functioning.

By associating these multimedia systems to the development of applications to the teaching/training of users, one disposes of an easy consultation way with the presentation of the thematic matters in an extremely pleasant manner. Fixing the user's attention and providing him a greater quantity of information and knowledge, than the traditional way of teaching. It may also be an extension of the laboratory class, where one must manipulate the various components, effectuating the real laboratory test of the various sorts of schemes, through the cylinders and valves disposition and consequent simulation of compressed air flowing through these devices.

26.1.1. *Motivation*

The optimization of the productive system as a whole, makes the training area to play a more and more important role, in the achievement of better quality levels of the productive process as a whole because, with the coming of more automated equipment which automation is becoming also more and

more important, the necessity of updating knowledge by the user is crescent, to succeed in the efficiency of all the industrial environment.

With the growth of computational means in all the departments of the organization, the users access facility is proportionate: to the consultation of training products to their personal satisfaction, to their teaching rhythm, to their disposability and place where they might be, in a quick and simple manner.

26.1.2. *Training/teaching and communication*

In the last decades, educational systems have been suffering frequent reforms, this is a result of the transformations inherent to the countries development, where psycho-pedagogical tendencies valorize more the trainee, with their different training rhythm, adjustments of contents to the various age groups, the development of cognition aspects that transmit mental capacities to the trainees, so that they may conceive the various aspects of knowledge [1].

Therefore, every communication way, consists on a message transmitted by someone, who works as the sender, to an addressee or receiver, where the transmission should occur with minimum losses of information. But, so that the communication may be established by someone, the participants must use the same language and, be familiarized with the transmission system, in such a way that technology, may be a means of establishing an effective communication.

By disposing of a virtual world, the trainee may explore, see, touch, feel, enthusiastically manipulate it, discovering a sort of simulated game, that proportionate an extremely motivated person's training, through the opportunity of learning by stages, by the productive process simulation, in this case, of the pneumatic area.

26.1.3. *Pneumatic Concept*

Knowing that energy is the capacity of performing work and that work is the product of a force by a displacement, it becomes vital that the transformation of an energy source into an energy form is extremely important to the control of energetic costs and to the consequent industry success.

So, the traditional cycle of energetic transformation in an industry passes as: electric power into mechanical energy and then, into pressure, from this the compressed air is an energy in a pressure form, which in a large number of organizations, becomes a second form of energy specially used in the transformer industry [2].

Therefore, whenever one tells that the compressed air transmits power through linear actuators (pneumatic cylinders, with or without piston and/or through rotate actuators (pneumatic engines), one is speaking of pneumatics. Its applications are pretty vast: hand braces, impact keys, robots and airbags...

It is very common that users prefer this energy form once, in the tasks of force to be performed, the weight of the tools, to the same power yet to be applied, is five times lower in a pneumatic tool, than in the same electric tool.

From this, it happens that an accurate production of compressed air, its treatment and distribution to various applications, is a factor of success, that must be initiated with the adequate knowledge transmission to users, at all levels in an organization, where the CAPneTS application is a model that intends to satisfy some of these requirements in the training and recycle of the human resources, that conceive and give assistance to this equipment.

26.1.4. *Virtual Reality and Multimedia*

The conjugation of these two technologies [3] to construct the teaching model shown intends to be a new alternative to the conception of products for Computer Aided Teaching environments. By using simulation of virtual objects through computers and an interface between a developed application and the user, we want to create a product which favourably satisfies the items for which it was created, despite some differences between the essences of a Virtual Reality (V.R.) and a Multimedia System (M.S.).

Although the V. R. system also process many data bases, the image constitution and its perspectives within that virtual world must be made in real time, with adequate program language and hardware where movement images are made.

However, and because the way of interaction with the objects creates by V. R. technology are still in increasing generalisation, namely the available peripheral, which satisfy the needs of moving objects and are largely diffused by the users/students [4].
But in a larger sense, the conjugation of several existing media (image, sound, text and movement) in data bases will not lead to the creation of a new virtual world, but of multimedia environment to which it is intended. However, V. R. consists on the creation of new environments representation of a reality of the physical world, but in a way, that is much more participate on the part of the user in manipulation those virtual objects, where the multimedia techniques are part of those means [5].

In order to achieve a correct maintenance, it is necessary to have human resources adequate to the organization's needs, once they assure a good equipment functioning and make possible to optimize the efficiency and the accurateness, under minimum costs.

26.1.5. *Human Resources and its Training in Maintenance*

During the industrial revolution, people were seen as parts of equipment, easily replaceable. Nowadays, people are the ones who make the difference in the organizations, being their knowledge an extremely important competitive advantage, not only to the success of the organization's strategy but also, to its survival in the market. In this context, possessing human resources adequate to the organization's purposes, correctly developed, motivated and with the appropriated training to the tasks yet to be performed, represents the main purpose of any productive sector, that really wants to keep itself competitive in the market.

A maintenance technician ought to be a specialist in his area, possess good knowledge in the remaining areas to which he is connected, is a good observer, sometimes self didactic, have critical spirit, dialogue capacity and dynamism.

Experience demonstrates that in order to obtain good results, it is fundamental to succeed in the participation of all the collaborators in the organization project, being created the necessary conditions, so that they give their best.

The motivation of a collaborator must not be exhausted in a punctual action; it must not be considered sufficient by attributing for example, a productivity reward but, a good teaching plan and a formal recognition for his good performance, should be created. The training and development of a professional career are important aspects to be seriously considered in the definition of collaborators motivation policies and, consequently, to be possible to achieve a quality improvement.
Due to some difficulties found in the slowness and way of working, plus the importance that training assumes in the motivation of human resources, it has been tried to create an assistance model to the

production maintenance and training, by using the multimedia environment.

This model CAPneTS, was expected to fulfill the needs that human resources face. As an example, a staff little motivated, belonging to a high age group and of low academic teaching, all these aspects, reflect themselves in the little objective way of detecting and analyzing the diagnostic deficiencies, the kind of stoppage in the production line, in order to find a quick and efficient solution.

26.2. DEVELOPED APPLICATION

26.2.1. *Purpose of the Work*

The utilization of multimedia environment integrated in the maintenance of pneumatic systems in an efficient and tutorial way, of easy manipulation, makes the developed application be extremely well accepted by the trainees, when one analyses the schemes complexity towards the user, presenting itself with its option menus with graphic visual .

This application may be used individually and in a remote sector of the factory by using a portable PC or by accessing to an organization's internal net - Intranet, which leads to an increasing of the maintenance work yet to be performed, if one has at his disposal the pneumatic circuits of each equipment installed.

Its actualization in a perspective of possessing new sorts of components information, for example: other sorts of valves not yet contemplated, are of an easy introduction, being the architecture of the system prepared to receive image, text and sound information. By this reason, it is a most relevant feature, so that it could be manipulated by non specialized staff in programming and, consequently, the database about the available components is becoming more complete.

26.2.2. *Functionality and objectives*

The developed model is an application that recurs to V.R and M.S. environments computational systems, destined to the industrial maintenance, with practical application in the packing productive sector, and in the human resources training.

This model associates theoretical concepts to the selected component, in the HELP icon, with 3D images, animated and with sound information in order to facilitate the comprehension and perception of the component and its scheme.

The main function of the created model is to solve difficulties, which are mainly:

Access to technical information, because it is often diffused and in foreign language;

Lack of knowledge as an important factor in the stoppages of the production lines;

Traditional training systems little attractive to the trainee;

Lack of self-training motivation;

The functions inherent to the manipulation of this model are:

Centralization of the information regarding a certain theme, since the theoretical concepts to some maintenance procedures; Motivation made possible through 3D graphic environment; Animation and sound resources; Visual memory assistant; Characteristics of several equipment; Display of the components geometry.

Probably, there is not a typical user of computer aided design - CAD. The needs of someone who designs architectonic equipment, are very different from the ones of a heating equipment or ventilation equipment designer.

The 3D objects conception of the real world, passes through a modeling process, of the entity to be represented, being used basically, the module *3DEditor* of the *3DStudio*-program [6], being created appropriated 3D volumes of pneumatic components.

univers.infr.sinc. 98
new technologies for higher
education

The 3D geometry manipulation, demands for a good notion of space and a good orientation of the work plans.

In order to fulfill surface layers with the desired materials, one has recurred to a module *Materials*. Being the movement/animation of the graphical scene, by means of the module *Keyframer* one of the created components.

In case we had given preference to the conception of 3D objects in another modeling system, we would have to proceed to its conversion, using the following commands *File/Load*, click on *.DXF followed by the file.

26.2.3. *Image and Animation Conception*

As a second stage in the system conception process, and after the various components modeling, one must place the proper materials in the objects and, give them motion.

By recurring to the *3DStudio* program, which is basically divided into five different fields like the *3DEditor*, *Shaper*, *3DLofter*, *Keyframer* and the *Materials Editor*, it is possible to simulate the device behavior, which constitute the productive sector, in its real forms. This will allow the transmission to the trainee, of proper knowledge to the functions he will have to know, through this environment.

The *Keyframer* produces animation; it disposes of functions that permit to work the image in dynamic terms on each component.

Fig 1 - Main areas of application architecture

The *Materials Editor* works the materials appearance in terms of colors, brightness and transparency.
Therefore, the schemer's skill in the creation of the objects, is a preponderant factor in the present system conception.

26.2.4. *Application's Architecture*

The application was developed by the conjugation of four programs, that permitted the creation of an integrated and multimedia environment. Having each one of the programs performed the following tasks: *3DStudio*, creation of models and animation; *Asymetric 3D* [7] animated input with sound and application output *Delphi* [8]; main menu containing icons that give access to four large areas designated as:
 1-Catalog;
 2-Pneumatic Components;
 3-Didatic Schemes subdivided into: Surfaces and Wires;
 4-Several, some images;
 5 –Evaluation;
 6-Help subdivided into main, suggestions, information; having as support the *Windows* environment [9], figure 1.

The navigation main element by the application is the mouse, making the selection and the interface towards the user, easier.
Inside these six large areas, selecting the respective icon, becoming available in Pneumatic Components the following components makes the access to its contents:
1) double acting cylinder;
2) 3/2 distributor valve with sphere;
3) 3/2 distributor valve;
4) 5/2 distributor valve - figure 2;
5) selector valve "OR";
6) selector valve "AND";
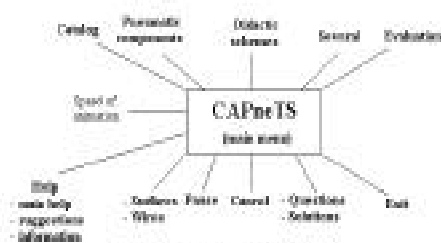7) strangler valve I;
8) strangler valve II.

Inside the Didactic Schemes icon, it is possible to access to several schemes, presented in sequence by crescent difficulty

of the desired kind of effect, in wires or surfaces model, to a better comprehension of the compressed air flowing inside the components.

The trainee may also choose the velocity

Fig. 2 - General view of 5/2 distributor valve

degree of the components movement, by selecting the icon in the application main menu, according to his comprehension degree of the compressed air flowing cycle in each scheme. This pedagogic aspect should be detached, once not all the trainees assimilate this system functioning in the same way. There is still a pause button to stop the scheme animation every time one wishes.

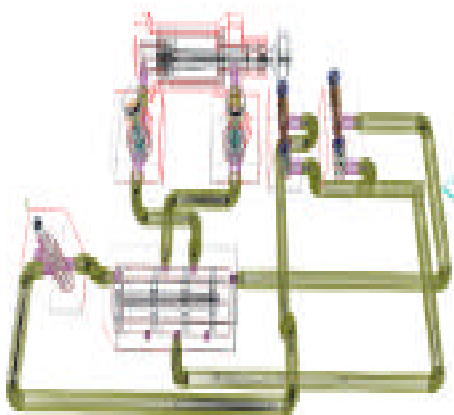Thus, there are five schemes created up

Fig. 3 - Indirect cylinders command (cycle by cycle) with velocity adjustment, in wireframes

until now:

1st- Indirect cylinders command (cycle by cycle) with velocity adjustment, in wireframes figure 3.

2nd- Indirect cylinders command, without velocity adjustment.

3rd - Bi-manual command with surfaces figure 4.

4th- Emergency stop with return to the initial position.

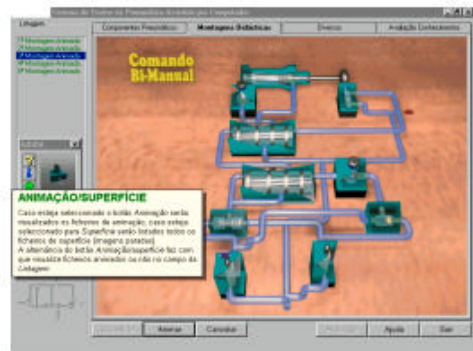5th- Command of two cylinders with external impulse.

Fig. 4 - Bi-manual command, with surfaces and associated information

Beyond images and text helps, the program has a background sound application, created with the purpose of improving the research environment and navigation inside the application, in order to attenuate the work "pressure" and to improve the maintenance technician performance.

In this model's structure, it becomes important to point out that it is composed by a main program developed in DELPHI programming language, which returns to subprograms *unit's*.
The user will only have to know how to navigate inside the main menu, and understand each one of the schemes to answer to the evaluation questionnaire in the end.

26.2.5. *Help*

In this area, the trainee is expected to accede to two help levels: general and relational, being the former composed by a recommendation set of the way CAPneTS system must be used and to whom it is addressed. While in the latter, exists a technical detail of each individualized component and, in a scheme, to be completely elucidated of its functioning.

Associated to this kind of help, it is available normalized symbols of the components - CETOP [10], individually or connected to a scheme.

The creation of this help, emerged from an analysis of true necessities, from a maintenance daily work, where the information resulted from the manuals of various equipment [11]. This fact, has to do with the interpretation easiness made by all the users of the displayed image.

26.2.6. *Evaluation*

So that the developed system may be a true computer aided teaching system, the part concerning the knowledge evaluation, is of an extreme importance because, the trainee has at his disposal a set of several questions of multiple choice, according to each one of the schemes already presented.

After he answers the questions, he will be able to make sure of his comprehension degree of each one of the compressed air displacements and of the components functioning, to the interpretation of a certain task performance, in each scheme.

To the self-correction of his answers, the solution is made available. In case the trainee does not achieve 4/5 of correct answers, he must repeat the exercises of superior difficulty degree, once he has not yet understood some aspects that must be completely dominated. In the productive area, the lack of knowledge of this or that detail, is rather onerous and when the physical forces involved are great, in the

productive sector machines, it may occur serious security problems. Therefore, it becomes essential a complete knowledge of the components functioning, to achieve the maintenance success, where the CAPneTS system is expected to be a means to that end.

26.3. CONCLUSION

Once this is an application that contains a great diversity of concepts and components, whether we speak of technique documentation gathering, translation, images and sound display, *software* development or, operational tests, the final performance has been considered pretty good, having in mind the analysis of the results obtained near the maintenance technicians and trainees.

Having as a starting point a model execution that transmits with simplicity the knowledge to the trainees and that gives them assistance in the maintenance procedures, the work performed seems to be of an extreme usefulness and opportunity, where the complexity and variety of components and machines are real, and where traditional acting methods show themselves obsolete, due to the process slowness and little credibility. But, with adequate computer applications to the assistance of the training and maintenance work in production lines, that involve a great number of automatism's and pneumatic components, there will be an improvement of the involved resources and a bigger motivation to those who use it.

The future improvement of this system will comprehend the agent's technology in the improvement of the help features and interface to the user, in technical details of the various components. To introduce greater versatility in the schemes conception, on the users side, by turning to learning process models supported by genetic algorithms, in order to lead the user towards the optimal solution. Improve the interface by the utilization of the data glove and objects

manipulation of the graphical scene, in the future conception of other schemes. To make the CAPneTS system available in the Internet to the remote teaching and to complete the evaluation module according to the introduction of new schemes, as well as to look over the didactic and pedagogical aspects, to make possible a better assimilation of these concepts by the trainee.

26.3.1. *Future development*

The introduction in the teaching system of news peripheral such as the data glove it will be a new stage of developing and it will be a future goal to expand the potentialities knowing. The systems will go to inside net systems to be use in remote areas such as: formation centres, through World Wide Web, they are same objectives to ahead.

Another improvement it will be introduction of ergonomic interfaces for the user to choose which the menu, he will enjoy to work.

The interest of the authors in these matters, does not end here, being both of them truly eager to achieve other academically degrees in a near future, by developing works in multimedia areas, virtual reality and man-machine interaction systems.

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eunenconfr v. scz. 98
new technologies for higher
education

27. THE POTENTIAL OF TELEMATICS FOR THE EDUCATION AND PROFESSIONAL DEVELOPMENT OF TEACHERS

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Abstract **- This article builds on a research project which aimed to find out how tlematics could enhance the process of education and professional development of teachers. The research design followed a case study approach and used multiple sources of data. The article presents evidence of the potential of telematics technology for environments of teacher education from its initial phases to continuous professional development.**

27.1. INTRODUCTION

With the growth of the Internet, telematics, as the application of information and communication technologies and services, usually in direct combination, has gained increased importance in education. Also in the field of teacher education, its potential has been researched.

The use of telematics in the context of teacher education and the professional development of teachers was the topic of research that led to the preparation of three case studies in the academic year of 1994/95. The Internet 'explosion', a period of exponential growth of telematics development and use, occurred during this time. When my PhD research (Osório, 1997) started, the word 'Internet' was familiar only within the academic and research community; at the conclusion, this phenomenon has become a reality of daily life.

The three case studies provide a good representation of the use of a range of telematics applications. They provide substantial evidence of the potential of telematics. They provide insights into the use of telematics in activities interlinking students, teachers and lecturers of different subjects (e.g. Mathematics, Language, IT, Professional Studies) and in various phases of schooling (primary, secondary, higher education). The case studies also offer an international perspective on the use of telematics by teachers working within the context of the educational systems of two different European countries, England and Portugal.

Telematics includes a wide range of telematics applications, most of which were used to support activities described in the case studies. The variety of teacher education activities that benefit from telematics is another way of demonstrating the merits of telematics. Moreover, the value of telematics for teacher education is highlighted by its capability of providing flexible and motivating new modes of communication.

I illustrate, in more detail, the potential of telematics for teacher education, as follows:

- ❑ range of telematics applications;
- ❑ variety of teacher education activities;
- ❑ new modes of communication and interaction.

27.2. RANGE OF TELEMATICS APPLICATIONS

Within telematics technology there is a range of software applications with educational potential. Various examples of these telematics applications were used in the three case studies. They comprised text

telematics and multimedia telematics applications as follows:

- ❑ email;
- ❑ computer conferencing;
- ❑ access to on-line information;
- ❑ desktop conferencing (DTC);
- ❑ video conferencing (VC).

This list offers already a considerable number of options, although each of the applications listed itself provides a variety of uses and may cover the features of other applications in the list. I illustrate this with the first and last applications indicated.

In its basic use, email was used for individual exchange of messages. This was so among student-teachers and between them and their tutors. I also relied almost entirely on email to collect information from activities in other country.

Email was also used for group communication through mailing lists, which may comprise a handful or thousands of members. Lists supported group activities restricted to selected users or, open to anyone, provided informal or moderated discussions. Mailing lists provided means to collect information and were used as computer conferencing. Mailing lists were used by tutors to provide information for their students and also to facilitate discussion among people involved in telematics projects.

Video conferencing, which developed from earlier desktop conferencing applications (Davis, 1994), was used for audio and video conversations at a distance, such as the supervisory video conferences between student-teachers and their tutors. The video conferencing software available provided the means for additional modes of interactivity or collaborative work. This included simple data file transfer, shared work on a common task (e.g. reading and editing a text or diagram) or remote access to multimedia information and other software packages.

In most of the activity I was able to follow, these applications were provided by different software packages/programmes. However, there were occasions when a number of applications were included in integrated packages.

Currently, these services are being replaced by HTML based services which increasingly include multimedia material (text, sound, image, video). Examples include web sites being designed within the framework of European Union projects for telematics in teacher education such as T36 and TRENDS7.

In addition, integrated packages offering a combination of various applications are being commercialised and their attributes and value for education evaluated by academics from various fields. For example, a recent discussion in the list <cmc-in-he@mailbase.ac.uk> — which allows discussion about the use of CMC in higher education — included reviews of packages such as First Class and Lotus Notes.

The range of telematics applications options available for an educational activity or project is wide and flexible enough to provide innovative and interesting experiences. These enable exposure to state-of-the-art technology. More importantly, these technologies appear to have an effect on the kind of communication that takes place. If email, for example, seems to support an informal type of communication, video conferencing, on the other hand, was described as requiring a much formal and intense mode of communication. In addition, telematics technologies appear to support and facilitate new and challenging modes of teaching and learning for teacher education, as presented below.

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6 URL - http://www.ex.ac.uk/telematics/T3
7 URL - http://bbsria.cet.pt/trends/trends.htm

27.3. VARIETY OF TEACHER EDUCATION ACTIVITIES

The case studies have shown there was a variety of teaching and learning activities supported by telematics applications. The extent to which telematics applications were used also varied. However, there was evidence of benefits resulting from telematics support. I illustrate this with the following teacher education activities:

- ❑ use of telematics in teaching activities;
- ❑ supervision;
- ❑ practice of teaching;
- ❑ training;
- ❑ administration and management.

27.3.1. *Use of telematics in teaching activities*

Telematics provides the means to support the 'delivery' of teaching modules, courses, seminars or lectures. In addition, a telematics project may be designed to include 'traditional' face-to-face activities in combination with on-line components. The virtual case conference (Kent, Herbert and McNergney, 1995) was one example of the former. The LuxLink conference format (see Osório, 1995) and the use of computer conferencing by student-teachers within a classroom are examples of 'traditional' learning activities enhanced through telematics.

27.3.2. *Supervision*

The use of telematics for supervision of student-teachers was particularly relevant in a context of increased school-based work. Through email, DTC or VC, tutors provided various forms of support for their students and developed ways of putting into practice the Exeter model of learning how to teach, which values the use of a criteria for argument to analyse episodes of teaching, during supervisory conferences.

27.3.3. *Practice of teaching*

Initial experiences with DTC consisted of enabling student-teachers to practice small episodes of teaching at a distance. Although this need has probably diminished due to increased school-based activity, such a use of telematics provides evidence of an innovative use of technology to allow student-teachers (or teachers) to develop skills of teaching. This applies not only to the act of teaching 'delivery' but also to the capabilities of planning teaching.

27.3.4. *Training*

Email, DTC and VC were used to support IT training at a distance. There were informal occasions when, via individual email, a technical task was explained. There were occasions when DTC was used to follow a programme of IT training for a teacher. These demonstrations of IT and telematics training through telematics have shown that similar approaches may be used for training of other topics or disciplines.

27.3.5. *Administration and management*

The use of telematics was also helpful to support the administration and management of educational activities. There were various examples of the use of email and other applications to support project management and the co-ordination and organisation of activities. There were also occasions when telematics applications were used to sort out practicalities, require and provide information, deal with administrative tasks. This may be seen as a minor use of telematics in the context of education. However, the increased adoption of telematics applications is a demonstration of its own value.

Most of the examples used to illustrate how telematics supports forms of teaching and learning for teacher education were relatively short activities. On occasions, the performance of these activities was

obstructed by a number of difficulties. However, my three case studies offered considerable evidence to show how telematics has a beneficial role in the continuing process of teacher education from its initial stages all the way through to career professional development.

27.4. NEW MODES OF COMMUNICATION AND INTERACTION

In the information age, one of the widely acknowledged characteristics of telematics is the possibility it offers of access to vast sources of information. This was shown by the case studies which provided evidence of searching on-line information, through OPAC's, databases, or web sites.

This use of telematics implies an individual, possibly lonely interaction between the user and the telematics service and represents the one-alone paradigm defined by Paulsen (1995). It sometimes provides an excuse for critics pointing out the negative effect of information and communication technologies in the development of social skills and behaviours. This is not completely fair because, at least in education, the collection of on-line information is very often carried out by people organised in small groups.

However, the more important and newer contribution of telematics for education is the provision of new modes of communication and interaction. This is so because telematics provides not only private individual communication but also group communication among small or large groups of people. This was well illustrated by the need to use telematics to maintain contact between tutors and students in school-based work or among teachers in isolated schools.

Borrowing Paulsen's (1995) terminology for pedagogical CMC techniques, I identify the following modes of communication and interaction, illustrated by examples from the case studies:

- **one-to-one communication** - communication between two individuals - email or video conferencing exchanges between student-teachers and their respective tutors; email exchanges between teachers and their project advisers;
- **one-to-many and many-to-one communication** - communication between one individual and a group - computer conferencing postings by student-teachers; video conferencing intervention of a librarian, in a conference abroad; lecturer's use of a mailing list to disseminate information for a group of students;
- **many-to-many communication** - communication between groups - email activities in Email Days; group writing of a story, within a group of schools;

The medium of communication when using text telematics applications was writing and most of the times was asynchronous. However, the use of multimedia telematics such as DTC and VC enabled synchronous audio and video communication. There were also occasions of synchronous communication in some computer conferencing sessions that took place in face-to-face activities.

With such a potential for communication, telematics applications provide the means for the creation of communities regardless of distance and strict timetables. This feature of telematics allows the development of international and cultural understanding and the involvement of those living in isolated locations. This was also illustrated by short activities within the case studies, including international video conferencing sessions and the email exchanges within small schools. In teacher education, this is important not only because the professionals can become involved in a wider professional community but also because these technology developments introduce new

edmedia/ed-telecom 98
new technologies for higher
education

educational dimensions which teachers need to be able to deal with.

The three case studies provided examples of activities offering a useful insight in the use of telematics applications for teacher education and for education generally. As in other studies (see, for example, Somekh and Davis, 1997), the potential of the technology to support and enhance teacher education and professional development was well illustrated through the use of a range of telematics applications, the development of a variety of educational activities and essentially by the demonstration that telematics has great potential to support and promote communication.

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28. TEACHERS TEACH; TEACHERS PROGRAM: LESSONS LEARNT IN DEVELOPING A DISTANCE COURSE IN EDUCATIONAL TECHNOLOGY

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Abstract - **This paper describes the evolution of a distance teacher education course, training practising teachers of English as a Foreign Language in various contexts around the globe to develop their own multimedia programs for their target learners. The types of delivery and support mode possible at distance are investigated briefly. The lessons learnt include observations about these various mechanisms. These, in turn, are seen in these preliminary analyses to relate to varying learning styles. Concern about the balance between teaching a skill and raising awareness about effective design of multimedia learning materials is discussed and the evolving design of this particular course demonstrates some of the answers sought to evidence of conflict when dealing with a potentially powerful authoring tool with teachers who, whilst being experienced in the classroom are, for the majority, relative novices in programming environments. It is argued that different modes of delivery and support within one course 'package' rather than a single uniform approach would appear to facilitate learning for the diversity of learner encountered.**

28.1. INTRODUCTION

This paper has arisen out of experience gained over the past 2 years from a fully distance Masters level course distance training of teachers of English as Foreign Language in educational technology and run by the Centre for English Language Studies in Education (CELSE) at the University of Manchester. The paper describes the evolution of the course in distance format and how that evolution has attempted to respond to both learning objectives and to the various needs of different learners who, whilst all being practising teachers of English as a Foreign/Second Language, nevertheless demonstrate varying levels of technological expertise and of course differing learning styles. Rowntree (1992) discusses how distance materials are often provided in a rather uniform design, often for very good reasons and Honey and Mumford (1986: 3) warn us that what is provided may in fact not be 'congruent with the way in which at least some of their ... students will learn effectively.' Such varying needs have been witnessed in the data gathered from the teachers taking part in this course, data in the form of ongoing comments and questions via an email support list. This data has been monitored throughout and has led to reflection by the tutors and ongoing modifications as the course evolved alongside the teachers themselves.

28.2. THE DISTANCE COURSE

To begin with an expose of the course and its aims as well as the teachers involved is necessary. The course in question forms part of a Masters in Education in Educational Technology and English Language Teaching. This is a modular course run fully distance and employs various distance learning delivery methods including paper-based materials, disks and videos and fully Internet-based materials. The course aims to develop not only the technical skills of ELT teachers in the different technologies but also, and perhaps more importantly,

awareness of appropriate methodologies for the effective use of technology in support of language teaching and learning. The distance learners are supported via various mechanisms, mainly using the tools of computer mediated communication: email (individual and lists), Moos and web-based environments such as Facilitate.com.

It is the developing technical expertise required of and needed by teachers that has raised issues relating to the nature of distance courses designed to develop that expertise whilst constantly keeping the pedagogic hat on. The specific module that has been carefully monitored in this respect has been one which aims to provide teachers with the tools to create their own multimedia computer programs. Let us remind ourselves that these are teachers who may have had very little experience of computer assisted language learning before joining the course. They do, however, come with at least three years of post-initial training teaching experience. The early modules of the course give them a grounding in longer standing CALL and introduces them to the full range of technology open to the language teacher: CALL software, the Internet, concordancing, generic tools such as word processing and databases and emphasises always an evaluative approach giving them the tools with which to evaluate good and bad practice. It is having gained that grounding that they come to designing their own programs.

The authoring environment within which these teachers work is Asymetrix Toolbook 4 (non-multimedia version). It is a widespread multimedia authoring tool used very often for educational program development. It is based conceptually on the notion of a book with pages onto which the designer can place different types of object which can be given certain characteristics or features to make them behave in a given way either through scripting or through the attributes available

to those objects. It was also chosen for its easily assimilated scripting language - at least certainly in the earlier stages of learning to program simply but effectively. For example, a request for feedback in response to a button click might be:

```
to handle buttonClick
if checked of button "two" = true
request "That's absolutely right."
else
request "Not quite right. Think
about the verb form here."
end if
end
```

For the learners (we shall refer to them as teachers), there is a comforting familiarity in this script. Toolbook is, however, a powerful tool, there is no doubt about that. The training of our teachers to handle the tool within their capabilities whilst producing programs that satisfied theirs and their learners' needs gave us the opportunity to examine various training and support tools that are available to the distance educator. Our findings are relatively preliminary but have provided valid directions for future research into distance learning of this type. The course is based very much on 'experiential learning' (Kolb, 1984), the provision of concrete experience from which reflection and generalisation might be formed by the learner him/herself. When the course was first designed, the teachers were provided with the tool (Asymetrix Toolbook 4) and the concrete experience of creating a multimedia program under tutorial guidance. The expectation was that they would then be able, with encouragement and support via an email list, to transfer that initial experience via reflection and generalisation to the production of their own programs. However, it is perhaps in the area of reflection and generalisation not simply of the technical skills they were developing but also of the methodological issues related to the design

eurocult.inf.conf. 98
new technologies for higher
education

on multimedia language learning programs that questions arose. Our constant monitoring and now subsequent analysis of all communications raise interesting questions about how both the attractions and the frustrations of the technical can easily take over from the methodological. They also bear proof of the need to provide for differing learning styles: a uniform approach is not sufficient to ensure generalisation and testing in new contexts. The following will present some of the evidence for this and discuss some of the strategies that we have evolved as experience of teaching by the course has developed.

28.2.1. *Teaching modes: tutorials*

A standard feature of many authoring environments is the notion of a tutorial. Toolbook includes a tutorial feature, introducing the novice user to its environment and the basics of programming in that environment. The teachers were first instructed to work through that tutorial as a starter. This did the job of initial familiarisation but no more than that. These are teachers who are not computer programmers and rarely come from that type of background. But what is involved here is not learning to become programmers but to be more informed about the design of computer based learning packages and how tools of the trade might be best exploited. During earlier modules evaluation of current commercial multimedia software for language learning had been a disappointing affair and armed with criteria for effective CALL, the aim is to develop simple but effective learning software.

The balance between learning a skill, however, and applying effective pedagogy proved a challenging one to achieve. The first stage was to provide them with a tailor-made tutorial designed in Toolbook using and demonstrating some of the features that

can be exploited to create effective CALL materials. The tutorial builds up a reading program with the teachers, page by page, exploiting features which allow the designer to create interactive tasks e.g. drag and drop, checking of boxes and subsequent feedback, ability to hide and show objects as wished. This tutorial package is the mainstay of the early months of teaching the learners how to program in the environment. But it was during this process that certain phenomena began to manifest itself in the student group. One of these was initial inability to transfer the guidance of the tutorial to a freer context.

> I find the CELSE tutorial 10 times better than the one from Toolbook itself. However I have got stuck on the button >drawing stage and thus am making zero progress. I select the button I want from the palette, the cross symbol appears >and I position the cross where I want the button to appear and then (regardless of which mouse button I click/double >click) nothing happens! Can someone tell me what I'm doing wrong?

The notion of creating 'buttons' is fundamental to navigational procedures in Toolbook. The tutorial addresses this in detail in the early stages. It is in fact a relatively simple process but requires the use of various 'tools.' The author of the above message has actually come unstuck in the very early stages of progam design and this feeling of uncertainty has also been noted during the face-to-face version of the same course. When the prop of a tutorial is taken away, a sense of inertia sinks in and transfer is not immediate.

28.2.2. *Support mechanisms: manuals*

A second mechanism open to the distance learner grappling with software is also of course the accompanying manuals. These are notoriously lacking in transparency for the uninitiated.

alt-c...nc. 98
new technologies for higher
education

>I'm finding it very difficult to find the information I want in the user manual because I don't know enough about the >terminology to find the correct page in the index. For example, I would like to get students to write some information in >a box before being able to move onto the next page of the program. How can I do this?

>A general problem with the user manuals and the on-line help menu is that they describe the functions of toolbook, but >what most of us need is a how to achieve certain effects manual (I find wading through the manuals very disheartening >at times).

However, the notion of a manual was an attractive one as we shall see presently.

28.2.3. *Support mechanisms: email lists*

The email list has proven the most vital of any tool in support of the distance learners. The list was also turned to more and more as the manual failed to provide answers. The frequency of messages grew rapidly as the course progressed to reach an average of 6-7 messages per day in the latter stages. This frequency of list usage and the nature of the queries reflected not merely difficulties but also the converse: the learners' growing confidence to become more individualistic and to approach their program design in a different way. In the early stages the teachers worked on reproducing what had been given. Task types reflected either what had been provided in the tutorial or slight variations. Messages later in the course illustrated how the teachers began to think about the ideal and look for answers that Toolbook might provide. It would appear to provide at distance the mechanism by which learners can construct their own understandings of input (Laurillard, 1993) as well as pose queries. Brown (1997) argues that: ' Simply providing information to learners, or even access to it, is not enough. Learners need opportunities to reflect on new material, discuss their tentative understandings, actively search for more information to throw light on areas of interest or difficulty and build conceptual connections to their existing knowledge base.'

However, in terms of managing the distance course, this also led to growing demands on the tutors. Although the learners were becoming more individualistic and creative in their needs, although they were seen to be testing the experience they were gathering in new contexts, the autonomy required to find all the solutions was not sufficiently developed. This was a bi-product of the uniformity of approach in the early stages. The 'tools of autonomy' were not yet in their possession. The guidance that had so desperately been needed in order to enable the teachers to get to grips with Toolbook had not provided them with a more generic understanding of its environment. The free rein witnessed in their questions prefixed by 'I'd like to be able to .....' could not be readily answered from their own experience. They became more and more dependent on tutor responses and it was realised that this needed to be tackled, that the 'connections with and between new and old concepts' (Brown 1997) needed to be more carefully built. The new and old in this case proved to be Toolbook and what they knew about effective teaching methodologies.

28.2.4. *Learning styles and teaching and support mechanisms*

Before examining how that bridge was built, a further interesting bi-product of the communications data was evidence of differing learning styles. As diversity grew and individual queries came via the email list dedicated to the module, there was growing evidence of differing preferences in how support was given. The course moved from providing a united route through the tutorial

to more individualised support via various mechanisms. It was clear that different learners responded more easily to the various mechanisms used. These included explanations on the asynchronous email list dedicated to the module and to which all learners were obliged to subscribe, synchronous on-line seminars at Schmooze University, sample Toolbook files attached to email messages to individuals and the use of Lotus Screencam enabling a 'Show me' approach to explaining what to do. The following is a response from one of the teachers on first receiving one of these files. It not only allowed the teacher to immediately 'see' the answer that had previously been attempted by email but this was also the first email message to show a willingness to have a go at solving a problem before asking for a solution.

>the software is excellent - I could see straight away what I had to do and it worked. Thanks! My next problem is >related to syntax errors with scripting buttons but I'll have a go at solving the problem myself first. I think I may have >created too many pages.

Different learners demonstrated an ability to 'understand' a solution in different delivery modes. Some were able to act immediately on emailed explanations; others required several messages reiterating a solution (evidenced by frequency of messages on the same topic) or immediately responded to the more visual mode. As the course developed, it became apparent that a variety of mechanisms were achieving the required levels of support. Sadler Smith (1996: 188) discusses how learning and cognitive styles might be catered for through a variety of instructional strategies. He discusses adaptive and non-adaptive approaches. In this case, we do not have an adaptive environment but have moved towards providing for variety in a non adaptive approach:

A non adaptive learning system may be defined in the present context as one which attempts to cater for cognitive style differences by multiple teaching modes within the same 'package'. This balanced design' would effectively be a cognitive belt and braces approach (Sadler Smith 1993: 72)

A further aid that was suggested by several of the teachers was an 'adapted manual'. The following describes:

>The most effective help I've received is via the e-mail list. It might be useful to develop a trouble shooter manual for >future groups as they are bound to experience the same problems as we have.

What would go into adapted manual? The ideas were various: how to achieve a certain task; how to do the unfamiliar without wasting time. The latter led to certain feelings of insecurity and even inferiority exacerbated by the 'open contributions' on the list where it was evident that certain teachers were coping with following better than others, although at the time, this was perhaps not really the case; it was simply that they had so far responded to the type of help given and those that felt it was more of an effort had not yet been provided with information in ways that were immediately digestible or appropriate to their learning style. Talk of the inexperienced versus the experienced was in evidence on the list as the course went by, while, in fact, everyone began as total novices. In the following the manual is seen as an 'answer to problems.'

> Since receiving your message about runtime, I spent the best part of a day trying to work out what to do. I agree with >Ed about people who are not too skilled encountering problems - I am definitely one

of them. The point I am trying to >make is that an awful lot of time is being wasted on things that seem very easy to skilled computer users/experienced >users of Toolbook. As deadlines are looming, panic takes over. I think that the suggestion put forward for a Manual of >ideas is a good one. Perhaps there could also be some practical tips e.g. relating wrapping programs with runtime could >be incorporated. There certainly have been many useful tips given to people on the list. It could be a sort of A to Z of >problems. Anyone else out there with similar frustrations?

The teachers at the end of the module returned to this idea, asking for a list of scripts for various functions. However, this may generate potential problems when we return to idea cited earlier that the aim of the course is to develop both technological skills and methodological awareness. The software and its mastery take over. The teachers are provided with 3 input units of paper-based debate and reporting of the research into multimedia and CALL. These also involve evaluating programs produced by previous participants on the course and program design in relation to needs analyses. The email list was used to prompt debate about the teachers' own experiences and about effective language learning and teaching practices with technology. These prompts drew very few contributions from the group. The majority of the messages analysed sought help with scripting, ideas to achieve a desired task, help with integrating other resources into the Toolbook environment. The idea of an adapted manual of scripts runs the risk of exacerbating this preoccupation with the technical skills as opposed to asking the question 'Why do I really want to do this and is it going to achieve some pedagogical end?' The following illustrates one such preoccupation:

> The flash commands work (they're really annoying). Unfortunately, they are too annoying. For some reason when I >left click on the button I don't get a response until 4, 5, or even 10 clicks! I wanted to throw my monitor out the >window and I am afraid my users will want to do the same.

The answer has been to delve a little deeper and analyse Toolbook in relation to the tools it might offer for effective language learning. Toolbook, as stated, is a powerful tool and one which has not come anywhere near being mastered in the scope of this module in the way it would on a computation course. But looking at what teachers might want to achieve in the multimedia environment and the task types that they feel to be methodologically effective provides some of the answers. The notion of interactivity within that environment is a key concept. Interaction is a key concept in language teaching. How might teachers achieve meaningful interaction between learner and program? What tasks facilitate learning in our traditional classrooms? To encourage the teachers to consider this more, a new Toolbook program was devised to encourage them to consider how the features of Toolbook might be used to create effective tasks to develop listening skills. The functions of Toolbook are seen put to work in certain task types and these in turn are used at different stages of the listening process i.e. pre, while and post listening. The program exploits among other features drag and drop in matching tasks; the use of radio buttons to select answers, the use of write-in text fields at user level to predict expected listening content, drop down combo fields for multiple choice, scripting of feedback and changing of fillcolour and strokecolour to provide visual reinforcement of feedback. More importantly the program treats teachers as listeners interacting with the program and then as teacher-programmers once more analysing how the program achieved its goal.

This has proven extremely successful in that the users have reflected on the tasks and how they have been created but also on the rationale behind the design. The program also provides a ready source of possible scripts for the teachers to call upon.

Out of this analysis has also come a supplementary Toolbook program that might come close to the adapted manual the teachers have requested - a book of tasks. However, rather than see this as an inventory of potential problems, twelve different tasks have been assembled each exploiting different scripting, not all covering all possible task types they may wish to create but enough generic scripts to allow wholesale 'borrowing' or mix and match. Tasks include cloze type tasks, simple animation, the use of pause features to allow a certain timing of tasks e.g. for skimming and scanning, the use of hide and show to reveal tasks in the staged way a teacher might do this in the classroom, scoring.

28.3. FINAL THOUGHTS

The distance module is, therefore, now made up of guided tutorial, a 'dynamic manual', a log of email-based questions and responses, paper-based reflection on research, Screencam 'show me' files which can subsequently have sound added. The course has evolved over its time in existence. It has provided us with insights into the delivery of distance courses of this type but also provided us with evidence of the need to provide support in varying ways. This is only a beginning. But this brief examination has provided us with directions for research into how distance education might be developed most effectively. We have learnt that varying modes of distance delivery will complement each other. But one final thought. In all of this, distance delivery has by no means reduced tutor involvement time. Perhaps eventually this will happen but that

involvement has been a necessary part of providing direction, helping the teachers to construct their own understanding. Frequency of tutor response and involvement on the support list will be one area for monitoring over the next year of the course. But for the time being we see that this is indispensable to the nature of the distance course. We are enabling teachers to gain the tools to respond to their own teaching contexts. On a face-to-face course for the teacher who has not understood the mechanics, tutorial time in front of the computer screen soon sorts this out. Providing and responding to that individuality is the challenge we face but so far the success of the experimentation has been in the excellent quality of program submitted at the end of the module as assignment. We have not yet got it perfect; we are nevertheless well on the way to understanding a little more about how best we can train these teachers that we will probably never meet face-to-face.

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29. EVALUATION OF PRODUCTION AND TEACHING BY VIRTUAL ENVIIRONMENT

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Abstract-**After a study of requirements both in teaching institutions/ training centers as well as in industrial enterprises, we built a tutorial system, which leads the student through the faces of production of Electronic Systems, more precisely Printed Circuit Boards (PCB). The student interacts with the abstractions supported by three-dimensional (3D) manipulation and by visualizing graphic scenes, visual vehicle used in transmitting knowledge. We also added textual information, sound and animation to those entities, resulting in a set of modules, which will lead the user to an easy assimilation of the subject and an improvement manufacturing techniques.**

Keywords: evaluation, virtual reality, teaching, manufacturing, multimedia and geometry.

29.1. INTRODUCTION

We created an application of Computer Aided Teaching based on Virtual Reality [1] environment and Multimedia technologies, starting with the capacity of representing 3D objects [2].

The application simulates the Printed Circuit Boards manufacturing process. This process, due to its complexity, usually leads to waste and low readability, giving great importance to the formative aspects providing a learning of every phase of the process in as easier, tutorial, interactive, efficient way where each student feels attracted to learn this manufacturing process.

29.1.1. *Training/teaching and communication*

In the past decades, the educational systems have appeared with frequent restructures as a result of inherent changes in the countries and of new psycho- pedagogical movements which value the student: new rhythm of learning, adequate of subject matters to different age groups, development of cognitive aspects in order to build different aspects of knowledge.

So, any type of communication consists in the transmission of a message to a receiver by someone who acts as message sender, with the minimum loss of transmission. But, in order to have communication, the participants must use the same language and feel at ease with the transmission system.

The student, having a virtual world, can explore it, see, touch, feel, manipulate it enthusiastically, and discover a simulated game, which lets him learn in a motivated way.

29.2. OBJECTS AND FUNCTIONALITY

The fact that a Printed Circuit Board goes through over six dozens operations through its manufacturing process makes it a demanding product at the quality control level. Many of the mistakes made are a result of the users not knowing about the production of several items of the process. It is necessary to create one application which, in a tutorial way, leads and explains which basic measures to consider in order atoning those mistakes. The transmission of manufacturing techniques, in an interactive way, in the construction of various phases of the Printed Circuit Board is the goal to reach.

Technologies such as Multimedia and V. R. are used where by combining sound, image, animation, text, interactive navigation lets the student have a learning system, possessing animation by movements.
Students that have shown an extremely high tendency in using the system are using the actual application. We have collected some data of some students, which show a higher level of understanding and higher knowledge of the production cycle of Electronic System, especially in building of Printed Circuit Board.

29.3. PRODUCTION

29.3.1. *System construction - model images*

A typical user of CAD - Computer Aided Design, is probably no existent. The needs for someone who projects Printed Circuit Board are different from those of heating equipment or ventilation engineer.

The conception of 3D objects goes through a process of modeling the entity to be represented, using a modeling system, like AutoCAD [3], with the assistance of its 3D geometric modeler.

The manipulation of solids geometry demands a good notion of space and a good orientation of work plan.

For the filling of surfaces, in the majority of parts/objects constructed and its animation for the creation of graphic scenes we used 3DStudio [4].

29.3.2. *Image and animation conception*

With 3DStudio (*3DEditor*, the *Shaper, 3DLofter*, *Keyframer* and *Materials Editor)* we were able to simulate the behavior of the mechanisms that make up the manufacturing system in their real shapers.

In order to have realistic environments, it is necessary to have colors very close to reality. Using the *Materials Editor* we created our own materials.

The object animation was specified with the *Keyframer.*

To build the paths for the objects, we used the functions in the *Path* menu. The paths were created in *Shaper* and imported to the *Keyframer.*

To create the entity Robot movements, accessed through the respective icon/ key on the main menu of the Teaching System (T.S.), we used *Hierachy\Link* to connect the various objects.

The function *Hierachy\Center\Pivot* admits the modification of the object reference center.

Before creating the final animation, we made an animation preview with the *Preview\Make,* which makes a sequence of monochromatic images of how definition to preview the type of created movements.

Preview creates a low resolution, black and white image. For the final animation we use *Render* menu function.

29.3.3. *Virtual Interaction*

As a way to integrated and manipulates the virtual environment, we used the Cyberspace [5] program, a set of C and C++ [6] libraries.

The Human Computer Interface was created with the Delphi [7] multimedia program module. We added a database, where we created the fields (image, animation, sound, information) of the chapters and the final presentation of the manufacturing steps.

As extra information to the image, we have a text about each chapter for a better understanding of the process and easy relationship between the student and the different system functions.

Each register of the database coincides with a chapter where other phases of the process can be easily annexed.

We can navigate through the chapter with help of the *Objectdbnavigator* function which permits jumping from one chapter to another. The connection of the main program to the virtual environments is possible by the so-called *CreateProcess* (figure 1).

We got, as result, a tutorial environment of the learning phases for the production of Printed Circuit Boards, widely used in projects of different areas in this institution and out.
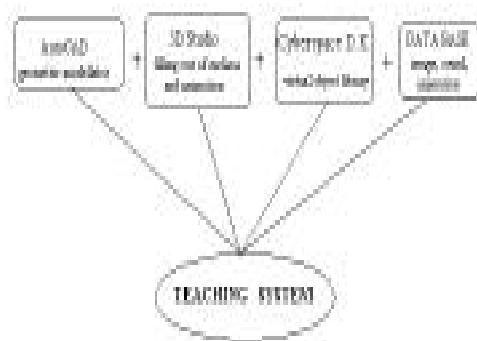
Fig. 1 – Connection of the used is developing systems

29.4. OPERATION

Initially the T. S. presents an overview of the Printed Circuit Board (PCB) Production Lab and of the various sub-systems within the production process. A detailed view of each sub-process can be presented using the main menu (figure 2), which allows the choice of one the nine available chapter in the application. The chapters are tutorials with animated images and texts for each of the production processes involved:

1-*Cutting*: The PCB board is cut to the required dimensions.

2-*Laminating*: The board is covered with the photosensitive film.

3-*Placement of the PCB drawing in the board:* Centralize the PCB drawing in the required position within the board.

4-*UV lamp* - Exposition of the board to UV light to impress the drawings.

5-*Developping tank* - The photo impressed drawing is developed (figure 3).

6-*Erosion tank* - The copper outside the protected areas is removed.

7-*Scouring* - The remaining protective film is removed.

8-*Tinning tank* **-** The copper tracks and pads are tinned and washed.

9-*Drilling machine* - The holes on the board are drilled, for small works.

Within the main menu, the user can interact with the application through the use of two button bars allowing the navigation between chapters and the control of the animations.

The supported options are:

Fig. 2 - General view of 2 chapter of system
Laminating the PCB board

- **Button bar to access the various chapters:** Moving to the beginning of present chapter, to the previous chapter, to the next chapter, to the end of present chapter and reload to refresh the screen.
- **Button bar to control the animation:** play, pause, stop, beginning, end, step forward, step back, to allow the control of the movement of the image and to interact with it.
- Within the main menu window there is also a **Description** field containing detailed information about the part of the process being visualized and a sound icon. In the lower border of the

Fig. 3 – Developing tank of the photo impressed drawing

There are also the following buttons:

- **About** - General information about the program.
- **Help** - Access to the help facilities of this application.
- **Manual** - Access the virtual PCB production lab in manual mode.
- **Robot** - Access the virtual PCB production lab in CIM mode (computer integrated manufacture-figure 4).
- **Factory** - Access to the virtual environment of production area that represents the architecture of PCB line.
- **Evaluation** – Group of questions abut the system and answers.

Fig. 4 - Virtual environment of CIM system with movements of robot by mouse interaction

- **Exit** - Exit of the system.

The advantages to have this virtual environment CIM are relevance, when the user do not have the real appropriate equipment, for the realization of the stage of machinery process and the result in one module of simulation and global learning of all production system.

29.5. EVALUATION OF LEARNING

29.5.1. *Evaluation of concept*

The evaluation is, in a global perspective, a mechanism that permits to justifiably maintain, change or suspend a certain plan or, in a pedagogic perspective, evaluation is teaching what has interest, improving the quality of what is accepted and eliminating what signifies waste [8].

Nevertheless, to evaluate may signify examining the degree of adaptation between a group of information, and a group of criteria, both adequate to the established purpose [9].

More specifically, evaluation level and in a learning context, is a complex method, due to the multiplicity of variables that affect it. From these, many are totally out to the

multiplicity of variables that affect it. From these, many are totally out of teacher's control, Who only directly acts upon some of them, but who must not stop having in mind the more complex sphere in which he operates.

Examples for these circumstances, it can be considered economical, political, socio - cultural and institutional variables, that in spite of apparently being distant, they reflect itself on the daily routine of teaching institution.

Regarding the evaluation of the process teaching- learning, we focus in one variable that concerns to the intervenients group, as, for example, the evaluation of the learning results from a class, made in the end of teaching unit.

In what concerns the nature of the evaluation from a process being under analysis, this can focus itself in the teaching dimension and in the teacher's performance or, it can preferably lean over "products", where the learning dimension and the student become the main purpose of the evaluation.

The incidence focus of this paragraph is particularly relevant in the evaluation of learning results from student / trainee, in the school institute context or, in the teaching center.

29.5.2. *Evaluation systems and its ways*

An evaluation system like any other system, is based on certain presuppose that, on one hand justify it, and on the other hand make it executable. Therefore, it becomes extremely relevant a planning of the whole teaching-learning of what is expected, in order to reach the learning purposes and also, the process conception.

To reach these stages, methods, means and materials are preponderant elements, as well as the way one knows if has reached or not, was expected – types and evaluation instruments will have to be deepened.

Basically, evaluation lies in three distinct ways. ***Hetero evaluation, self-evaluation*** and ***mixed evaluation*** according to the agent who evaluates [10].

29.5.3. *Results of learning*

One of the most important evaluation value consists on permitting the detection of a learning deficiency as soon as it happens, to immediately overcome such difficulty. In case students / trainees are not evaluated, they will keep going through several teaching levels or modules, without knowing what are their faults, being then detected lacks in other learning levels, difficult to surpass.

In this case, evaluation must not have a selective character, but it must have a constant sense of help and orientation to the student.

In fact, evaluation indicates us if each student is overcoming the purposes legally established that society demands to its members: this translates itself in the concreteness of an outstanding performance.

In conclusion the evaluation allows us to know our strong and weak points of teaching and learning, and consequently, will make easier its correction and improvement. In other words, the essential functions of evaluation in the educative domain are basically three: diagnosis of the process and of the educative product, prevision of students possibilities, having their personal scholar and professional orientation as the basis, and finally, to accomplish the permanent educative process control and also the students control.

After two tests have been presented: tests from the cognitive area, of paper and pen, of answers to be selected, of several type answering options [10], having the students learned the concepts to be transmitted in traditional way of teaching in the former, and having the T. S., in the latter.

As partial conclusion, it can be said that in the context of both tests, there was a global improvement of students, after they have tried the computer aided teaching system, having been, in this case, more motivated in the technical details of the subject, and having them been allowed to have a greater autonomy in the overcome of their individual difficulties and according to each one's learning rhythm.

The use of techniques that stimulate the student to better comprehend the training unit contents, by turning to the ergonomic interfaces, and to the informative boards consultation that follow the images, awake the trainee's curiosity, which gives rise to the motivation for a deepening of details, in what concerns the technologies inherent to these kind of components making.

The T.S. application, is a vehicle that will allow the trainee to ennoble his knowledge, being then reflected in the production stage, the existence of a reduction in the manufacturing errors and greater improvement of the material means involved, with a consequent optimization of the manufacturing timings, and a greater final quality in the several sorts of component plates to produce.

29.6. CONCLUSION

Students can achieve a higher level of learn, because they have a system were they can experiment the different stages of the building of the electronic boards.

In spite of a great complexity of systems of multimedia and Virtual Reality envelope its possible to create a Teaching System, in use in Technologic High School, for to teach this disciplines and external courses.

At operation level the system are very friendly to use and lead the user a fast learn of the board's production process.

29.6.1. *Future development*

A new version of the system built with Java and VRML97 will be available through World Wide Web.

Another improvement it will be use of sound information associated to the peripheral that manipulate the object, also introduce the agent concept more detail, he will enjoy to work.

The work will continue as part of the first author Ph.D. work on Multimedia, Virtual Reality and interaction between human a machine on the learning processes.

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univers.ofr.vinci. 98
new technologies for higher
education

INDEX OF AUTHORS