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Internet, Multimedia and Virtual Laboratories in a 'Third World' Environment

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ABSTRACT *Electronic education faces similar difficulties in low-budget institutions throughout the world (many of them in common with developed nations), including mainly rejection or disinterest from staff and students, insufficient funds, outdated hardware, incompatible software and poor Internet access. Over the past five years, with low budgets and considerable limitations in the equipment available, the Universidad Estatal a Distancia in Costa Rica has produced multimedia courses and materials for use on the Internet, as well as designing virtual laboratories that can be run on cheap computers. The authors recount their experiences in the hope that these will prove useful to others. They explain how simultaneous production of traditional materials (mainly printed textbooks) and online courses, together with simple automatic evaluation and 'outsourcing', reduce costs significantly. They conclude that HTML and JA VA are currently the choice computer languages to reach the greatest number of users without need of a specific computing platform, powerful computers or expensive software.*

Introduction

For the past five years, working with a very low budget and in spite of significant hardware limitations, we have produced courses and educational material for use online (via the Internet), based on multimedia applications, and designed virtual laboratories that work on cheap computers. We summarise our results in the hope that what we have learned will be useful for low-budget institutions in certain areas of the USA and Europe, as well as for most universities in Latin America, Asia, Africa and the Pacific. In particular we show that in spite of a poor history of adaptation to technological change, a distance teaching university can take advantage of currently available technology to automate the production of electronic material. We explain that simultaneous production of traditional materials (mainly printed textbooks) and online courses, together with simple automatic evaluation and 'outsourcing', reduce costs significantly. The conclusion is that HTML and JAVA are the computer languages that reach the greatest number of users because they do not require a specific computing platform, powerful computers or expensive software.

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The Wider Context

Our experience within the Universidad Estatal a Distancia (UNED) needs to be placed within a wider context. Electronic education has become a central issue in distance teaching universities as Internet use has grown significantly, and because there are new needs that range from the ageing of the world population (the experience and responsibility of senior citizens make them good distance education students (Villegas, 1998)) to school massacres that lead parents to search for education-at-home options (Monge-Nájera *et al.*, 1999). In poor countries, universities that in the past only faced local competition must now compete with institutions from Europe and the USA that, thanks to the Internet, offer online courses with practically no need to invest in the countries where they expand. Additionally, in Latin America the market is also open to the growth of small private 'garage' universities that reduce costs to the extreme. They mainly teach business administration and do not spend on scientific research. In

order to compete, universities in developing countries must develop an online capability. Like Nilsson et al. (1998) in Sweden, while selecting web links for our electronic courses, we found that claims about the futility of preparing original material because 'you can find anything on the Internet' are, at least for the moment, a myth. In any case, if these are protected by stringent copyright terms and subject to charges for use, it is unlikely that they will be useful for the small institutions that most need them. We conclude that for the foreseeable future many universities— including those in Third World countries—will have to produce their own online educational materials.

With few resources, technical limitations and poorly trained staff, this is problematic. These problems are not, however, restricted to developing countries. In our view electronic education faces 21 basic problems everywhere in the world (Monge-Nájera *et al*., 1999) (see Table I), and while we recognise that reclassification would change the precise number of problems identified, after checking all the papers from the VIII through XI International Congresses on Technology and Distance Education, we are satisfied with our classification. We discuss these problems below.

Problems Between Humans and Machines

The first eight problems (Table I) are strongly related to the difficult relationship existing between humans and technology. These problems have been studied recently by Perdue and Valentine (2000) who found that even when leading edge hardware and software are available, many people do not use computers because they prefer traditional methods or distrust the quality of electronic educational material.

Our experience is that in UNED the widespread problem with electronic education is that both students and staff are not familiar with it. Even though they have heard about multimedia encyclopaedias, for example, they generally see computers as the realm of younger generations. 'Actitudes', a word we derive from the Spanish *actitud* to convey the predisposition people have towards some subject, are negative, ranging from lack of interest to open rejection.

When forced by circumstances to use computers, those with negative actitudes limit themselves to basic word processing tasks and rely on their children or friends for everything else (adding software, fixing problems, etc.). Their actitude may also be associated with their experience with an older means of technological education: television. In its first years, UNED broadcast lessons through national television. Originally, a teacher worked with a blackboard in front of the camera, but this primitive approach (which has returned recently in industrialized nations in the form of teleconferencing) was abandoned. Today, UNED's television unit does not broadcast and has redirected its goals to the production of documentary videocassettes with better postproduction than in the early years. However, these videocassettes are rarely used in UNED's courses. More frequently they are produced on demand for third parties, thus producing an income for the institution. Within UNED educational television is to some extent perceived as a failure.

Previous to our experience with virtual laboratories, UNED made a few attempts at teaching through the web by hiring software and Internet access from foreign companies, but the fact that they were discontinued reflects technical, economic and pedagogic problems that range from the bizarre (having the students together in a classroom with computers connected via an intranet because the web connections failed outside the building) to the obvious (the facility of sending e-mail questions and comments resulted in teachers being overwhelmed by an excess of e-mail messages, to the extent that they found that traditional teaching was less demanding). A further aspect is that some of those who have used electronic educational material, mostly compact disc games and encyclopaedias, are not satisfied with the quality of the material. The products available throughout Latin America are mostly translations of English language material made in and for Spain: they are not adapted to the Latin American context. Another common critique is that electronic material production is dominated by computer technicians and not by educators, resulting in a clear predominance of form over content.

TABLE 1. Basic 21 problems of electronic education

Problem	Reference
(1) Teachers not properly trained in the new technology	Rodino 1998
(2) Few students take electronic courses	Kochman 1997
(3) Lack of interest or open rejection by teachers and administrators	RodrIguez 1997 Cedillo 1998
(4) Courses and tools are developed by computer experts who ignore teaching principles	Chadwick 1998
(5) Exchange facility (e.g. e-mail) lead to abuse: teacher is more overworked than in traditional courses	Laaser 1998
(6) Some electronic means such as traditional television favour student passivity	Chadwick 1998
(7) Having a computer does not improve student achievements	Chadwick 1998
(8) ' Virtual' and 'distance' education are inferior to real presence	Chadwick 1998
(9) High management costs	Kochman 1997
(10) Institution does not respect/pay authors' rights	Kochman 1997
(11) Frequent abuse (non-payment) of copyrighted material	Araya 1998
(12) Insufficient funds for appropriate technical support	Gueulette & West 1998
(13) Expensive technology	Kochman 1997
(14) Read only media such as CD-ROMs cannot be updated	West 1998
(15) Software failures	Kochman 1997
(16) Failures in computer hardware, and in audio and video equipment, that often persist for years	Kochman 1997 Araya 1998 Gueulette & West 1998
(17) Incompatibility problems with hardware and software	Gueulette & West 1998
(18) Vulnerability to informatic virus	Araya 1998
(19) Slow transmission of graphics and other large files	West 1998
(20) Abundance of Internet material saturates and misguides the student	Laaser 1998
(21) Non existent or expensive Internet access	Araya 1998

Source: Monge-Nájera *et al*., 1999

Economic Problems

Problems 9-13 in Table I are financial problems. In part because of its greater complexity, electronic education can be more expensive than traditional textbook- based education. In 2001, good multimedia personal computers can be purchased in the USA for just under US$900, and in Costa Rica for $1,300. While this represents a fraction of the monthly salary for the American buyer, for the typical Costa Rican consumer the cost of one computer represents more than three months salary (and remember that Costa Rica is among the richest nations, per capita, in Latin America). The same applies to software and Internet access costs.

These costs are presented to give international readers a realistic idea of the economic limitations of electronic education throughout the Third World. The same applies, of course, to educational institutions, traditionally limited to obsolete equipment (for example, until recently most computers at UNED were on average 10 years old) or, in the 'best' case, to a very small number of modern machines unavailable to most of the staff.

Too often, Third World institutions seem to be at the mercy of the salesman, who typically make an impressive presentation of technology to the authorities. They then buy a small number of machines at a disproportionately high financial cost to the university, only to discover later that there are no funds left for hardware maintenance, software updating and technical support, not to mention the production or acquisition of contents to be transmitted with the hardware.

Technological Problems

The final type of problem (Table I, problems 14—21) is the technology itself. Problems associated mainly with the computer include software failures and viruses. These are well known to users both in the First and Third Worlds, so there is no need to elaborate other than say that things are worse when funds to solve such problems are at the Third World level.

Hardware problems are related to local equipment and communication networks. The newer the machine, the more likely it is to fail, because older equipment was simpler and has usually passed the test of time. Kochman (1997) described his first day trying new technology with a real course as 'the longest day in my life'. In UNED, as in other Third World institutions, having a computer repaired can take weeks or months, and there are no spare or replacement machines to use while one waits.

In Latin America, which is far ahead of Africa in Internet development, just connecting to the Internet with a modem (nearly the only option) may require 10-30 attempts if you are using a public university service, as nearly all students have to do. Furthermore, there is no option of streaming video or

other broadband applications, because most machines are equipped with 28k modems. However, not even this low speed is reached: network limitations reduce real speed to 3-10k. Under these conditions, even simple pages with a few graphics are slow to load and most recent developments such as videoconference, or even audioconference, are impossible for the average web user.

In the following sections we explain how these problems added to UNED's own difficulties with distance education and how, after several years, we were able to overcome all of the above problems without significant budget changes.

UNED's Bitter-sweet Experience with the New Technology

UNED has over 20 years of experience but has been clearly unprepared for technological change. In this section of the paper we explain how we successfully adapted to electronic education in spite of the inadequate conditions we have faced (including an erratic and generally poorly resourced institutional commitment to research).

When in 1997 we began to address the production of Internet-based courses and the virtual laboratories, UNED had been experimenting with electronic mail and multimedia since 1993. In 1998 Gutiérrez *et al*. reported that electronic mail was 'a nightmare for users' and the original *ToolBook* multimedia were not used on any courses despite the previous five years of training and experimentation. In 2001, the same is true of the *ToolBook* multimedia but use of e-mail has increased because the DOS system was changed for a more user-friendly web-mail system in mid-2000. The Silicon Graphics videoconference material was, to all intents and purposes, not used following its development in 1994, while the network teaching tools *Quorum* and *Learning Space* (Cisneros, 1998; Cruz et a!., 1997, 1998; Rivas *et al*., 1997; Gómez & Rivas, 1998), tested in 1997, were not being used, and the seven courses designed with them were unfinished (Gutiérrez et al., 1998), as they continue to be in 2001. Earlier attempts with video and audio were also discontinued in the 1 990s. Students did not receive marks for using them, most did not use them, and the value of those methods was never evaluated (Gutiérrez et al., 1998), albeit experience elsewhere indicates that even interactive television (often via compressed video) is expensive, troublesome and unsatisfactory in many cases, reaching a 90% failure rate (Kochman, 1997). Again, the above 1997 and 1998 accounts are still valid in late 2001.

The value of new technologies normally is overestimated (D'Alton, 1997), as is the importance of information available on the Internet (Torok, 1997). Printed book distance education is cheaper than standard education (Bolaños, 1997), while electronic education normally requires more teacher-hours than traditional distance education, contrary to the popular belief (Torok, 1997).

In addition to the situation within the University, we also had to consider the characteristics of our students. The typical Latin American distance education students are female, around 30 years in age, seldom attend tutorial meetings, have jobs, and in 50% of cases are married (Bolaños, 1997; Cortiñas & Novello de Mettler, 1997; Cruz *et al*., 1998). Most cannot read English, require a mean 7.5 years to graduate, and a decreasing but yet significant proportion are not familiar with computers or the Internet (Cruz *et al*., 1997; Monge-Nájera *et al*., 2001). Nevertheless, innovative schemes, such as a student fund to buy new computers (Sandoval, 1998), the availability of government financed free access to e-mail-enabled computers throughout Costa Rica, and the finding that previous experience is not necessary for successful adaptation to computers, at least for Costa Rican distance education students (Seas, 1998), suggest that computers can play an important role for UNED in the future. This will be true even in new fields such as teaching impaired students, who traditionally have a very high failure rate (nearly 90%, c.f. Herrera 1997).

Nevertheless, computers can actually help overcome emerging problems. At UNED the administrative decision to reduce course length from six to four months made some experiments, particularly in agriculture, impossible because the experimental organisms require six months or more to develop. In this case, accelerated growth patterns can be simulated in a computer (Rodriguez & Vargas, 1998).

What We Have Done

In order to ensure that UNED can capitalize on the potential benefits of the new electronic technologies, we have adopted a range of strategies to overcome the problems that we have faced. These are described below in the hope that our experience will be of use to others who find themselves in the same situation as we did.

Finding an Easier Way to Produce Hybrid (Printed-electronic) Courses

From the very beginning we were very concerned about quality issues. 'Third World' printed textbooks are traditionally inferior to those produced in Europe and the USA, specially in editorial quality and graphic design (Núñez, 1997; Víquez, 1998). We wanted to avoid this 'tradition' by preparing electronic support material, courses and virtual laboratories that did not look 'second class'. Our first attempt was the development of an electronic version of a book resulting from an international symposium that we organised in 1997, The Biological Origin of Music (published online in April, 1998 at www.uned.ac.cr/ciac). The document is illustrated with classic paintings and photographs of ethnic instruments that reflect the content of the symposium papers; the visitor can listen to music played on ancient and indigenous instruments and even to the sounds of mammoth bones. This was done at practically no cost because the Editor donated all the work involved in translating the digital files submitted by participants to HTML and other Internet compatible formats.

Success with the symposium led us to experiment with our first online course. There are a number of features of our work that we believe will be of interest to those facing similar resource constraints to the ones that we faced. For our first online course, we selected tropical biodiversity because a printed book on the subject was in early production. By producing both the printed and the electronic version of the course simultaneously (Monge-Najera et al., 1999), we reduced costs to just an additional US$500 for the electronic version (over and above what had been spent on the printed version), because illustrations and text production were covered for the printed book, whose files in MS Word 7.0 were translated to HTML by copying and pasting into MS Front Page 97, a software that was later used to define layout and links. Image definition was reduced to 72 dpi (the printer uses 240 dpi) with Adobe Photoshop. The cost per course was 25 times lower than in Canada (Robertson & Mattock, 1998).

We decided to make this course available free of charge to our students, both as a public service and to test the software more widely.

Automatic Drill Evaluation as a Means of Containing the Costs of Assessment

At the end of each section of the book on our biodiversity course, the student is presented with multiple choice drills and, through a careful use of links, either sent to the next lesson or, if their choice was wrong, to a page that advises further study of the lesson. Whereas our software requires students to select from a list of previously written answers, more sophisticated automatic evaluation exists in Japan for mathematical and foreign language learning. This is because the computer can distinguish between correct and incorrect answers without the need for multiple choice answers (for example, by distinguishing grammatical errors in a freely typed answer) (Jussila, 1998).

Navigation and Communication among Students and Teachers

Electronic mail is not properly used by many students and often overloads the teacher (Laaser, 1998), while electronic chats reduce participation and require time synchronization (Pensa & Sabulsky, 1998). Accordingly we chose a Bulletin Board System which prevents these complications by accumulating questions, answers and opinion in searchable form (Olmstead, 1997; Bailey & Luetkehans, 1998), increases participation of shy students and increases the quality of language composition (Nilsson et al., 1998). In a BBS system, a database receives comments, questions and answers typed directly by the students or staff, and automatically posts them in the web page in real time.

Use of Digital Robots and Academic Freeware to Save Money

We are very satisfied with the quality of the resulting material, which meets international requirements (see Dooley & Edmundson, 1997; Gueulette a al., 1997; Arguea & Cañas, 1998). All our courses are in HTML, which makes them useful in Macintosh, Windows, Linux and other operating systems. They can

be copied and distributed on diskette, CD-ROM, tape, via the Internet, etc. This eliminates the problem of slow or expensive Internet connections except when the Bulletin Board System is required. Printed ready QuarkXpress files can be automatically converted for the World Wide Web with software such as BeyondPress, Challenger XT or WebXPress (Cruise, 1998) with 'digital robot' software whose price ranges from US$200 to $2,000. In poor areas such as southern USA, Asia, Africa and Latin America, the low costs of hybrid production should be particularly attractive.
Even if a low budget prevents the use of commercial software, money is not a valid excuse: everything you need to produce electronic courses is available for free. For example, Tropiweb (www.ots.ac.cr) has tested virus free freeware that we have found useful for our work, as follows (function: freeware name):

• Word processing: WordWorth.
• Image Manipulation: Imagewerks.
• Image conversion and storage: XNView.
• HTML editor: AOLPress.
• Web browsing and using the course: AOLPress.
• Multimedia: IrfanView.
• Uploading the course, for example, to a free page hosting service: LeechFTP.
• Agenda, student marks database, etc.: Skwyrul.

Solving the 21 Problems of Electronic Education

To avoid the 'shoot the verb' approach of software experts who develop courses, we inverted the formula: the courses were developed by teachers who learned computing skills, not the other way round. In a few weeks of mostly auto-didactic study, we learned enough to avoid most calls to the technical support department (which in any case is non-existent in UNED). We saved the small budget we had available to hire technicians for specific goals (such as organising the Bulletin Board System). This prevented all the problems associated with in-house technicians.

Copyright problems were non-existent because we used the original material produced by the same team for the printed book. Following joint work by our team and the legal department, UNED now has a contract form that covers authors' and institutional interests for both printed and electronic educational material.

We created interest in teachers, students and other parties by:

(1) Informing the media. After a failed attempt to do this through the institutional public relations department, we sent information directly to the media and got coverage on two television programmes and one newspaper.

(2) Including public shows of the courses at the periodic meetings of the academic schools. Practically all scepticism disappeared as teachers saw the courses operating on their own hardware.

We were not plagued by informatic viruses, hardware failure, and software incompatibility or 'bugs', because we rejected the use of 'the most recent update' that salespeople would like us to have. We limited ourselves to the older, tested software and hardware we were familiar with, and never regretted our decision. Student passivity was avoided by using HTML, which requires frequent input to navigate the course. We left space for real practical activities (we agree that virtual experiences cannot fully substitute for 'the real thing'), and we reduced the problem of Internet overload by making courses as self-contained as possible, and by including selected links only.

There are, however, other factors that explain our success in an environment of infrastructure and budget limitations: firstly, our department heads always supported our work, and secondly, we believed deeply in what we were doing. If these two ingredients are absent, even an exorbitant budget may fail to produce satisfactory results.

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