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ABSTRACT

This monograph combines an examination of theoretical issues raised by the introduction of two-way video and similar systems into distance education (DE) with practical advice on using compressed video systems in DE programs. Presented in the first half of the monograph are the following: analysis of the intrinsic links between DE and technology and overview of the new technologies available to distance educators; description of three generations of educational technology (correspondence, teleconferencing, and computer-based technology) and discussion of their applications in conventional education and DE; and outline of the history of virtual systems and their implications For creating virtual classrooms and teaching face to face at a distance. The second half of the guide, which is directed toward individuals interested in compressed video teaching, contains the following: terminology related to video communication and teaching; factors responsible for the rapid growth of videoconferencing; list of challenges to DE research; examples of successful experiences with compressed video teaching in Australia, the United States, the United Kingdom, and Norway; technological considerations in preparing for compressed video teaching; and 31 didactic strategies for compressed video teaching. Contains 18 refrences. (MN)

FernUniversität
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ZIFF PAPIERE 101

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Distance Education Technology for the New Millennium: Compressed Video Teaching

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CONTENTS

1. HARBINGERS OF THE NEW MILLENNIUM

As the new millennium approaches a major task for the field of research known as distance education is the analysis of the breathtaking array of technologies already developed by the telecommunications industry and now ready for implementation in distance education.

These include: universal mobile telephony, satellite virtual classrooms, universal personal telephony, fibre-to-the-local-loop, two-way video codec systems, videoconferencing to the desktop, broadband ISDN, the Internet, multimedia to the home.

These technologies are already developed. They may be regarded as harbingers of the new millenium. The task for the field of distance education is to evaluate their educational effectiveness and their cost effectiveness as a means to harnessing them for use in distance systems.

It would take a volume or a series of volumes to evaluate all the technologies listed above. This monograph chooses one for presentation: two-way video, two-way audio compressed video codec teaching.

The choice suggests that it is a technology that is here to stay, that it is not a gimmick whose appearance in the distance education literature will be fleeting and that the learning of the skills of using it competently and effectively are recommended to all distance educators.

It also suggests that it is an exciting technology with far-ranging consequences for teaching at a distance. It is a technology that has made it possible for the first time in history to teach face-to-face at a distance. By electronically linking instructor and students at various locations it becomes possible to create a virtual classroom. A student fidgeting in Hagen could disturb the instructor and the rest of the class in Dublin or students in Dublin could interact with students at Berlin or Boston if they are linked in a virtual classroom.

Most of the benefits to students of distance training systems are retained but the defects of teaching at a distance which have caused hesitation in the acceptance of teaching at a distance: delayed feedback, the artificiality of the student-instructor relationship, the lack of interactivity and, above all, the lack of eye-to-eye contact and interpersonal communication in the educational process, are electronically restored.

The first part of this monograph addresses theoretical issues raised by the introduction of two-way video, two-way audio codec systems into distance education and the problems they pose for distance education research. The monograph would be incomplete without a hands-on section at the end, telling the reader how to do it and giving advice on setting up systems and choice of didactic strategies.

2. THE ROLE OF *FERNSTUDIENFORSCHUNG*

The didactic possibilities of the technologies listed are immense and although they will have implications for students who travel to schools, colleges or universities, their major application will be for those who cannot attend classes or choose to study at a distance.

Distance education and technology are intrinsically linked. The developments in technology of the Industrial Revolution in the mid-19th century gave birth to distance education (Peters 1973). By separating the teacher and the learner(s) and using technology to establish communication between them it became possible for the first time in history to teach at a distance.

Distance education and training result from the technological separation of teacher and learner which frees the student from the necessity of travelling to a fixed place (school, college, university) at a fixed time (school timetable, training schedule, lecture programme), to meet a fixed person (teacher, instructor, professor) in order to be trained or educated.

As the particular focus of the fields of distance education and educational technology have sometimes been confused, it is of value at the outset to indicate how they will be distinguished in this monograph.

The field of study known as educational technology is the proper field for the study of the use of technology in education: It studies the use of technology by the 600.000 000 students in conventional schools, colleges and universities and the more than 30.000.000 enrolled in distance education courses today.

Three major articles by Hawkridge, director of the Institute of Educational Technology at the Open University of the United Kingdom have set out the parameters of the field of educational technology. In 1976 in the *British Journal of Educational Technology* under the title 'Next year, Jerusalem, the rise of educational technology' he analyses the philosophical underpinnings of the field and its range of interests.

The unusual title of the article indicates the euphoria with which most new technologies are welcomed by engineers and journals of education as they present a panacaea that is to solve all educational problems in the future. Too often, a decade later the technology has failed to establish itself as a valued component of distance systems and does not figure in the journals.

By 1981 Hawkridge made another major contribution in the same journal with the title 'The telesis of educational technology' tracing the many efforts made in the field of taking the teaching-learning process out of the hands of teachers and giving it to instructional designers and technology-based materials. A final article 'Challenging educational technology' in 1991 showed the field under threat from four forces: the challenge of cognitive science, the challenge of information technology, political challenges and radical critics.

Major contributions to the delineation of the field of educational technology were also published by Sauvé in 1991.

The position taken up here is that it is the role of the field of educational technology to study the suitability of each new technology for education in general but that the specific study of the technology in the context of distance systems is the task of distance education research.

It is considered also that the range of new technologies listed above, while they will undoubtedly impact on didactic strategies for students who travel to conventional schools, colleges and universities, will have their major contribution for students in distance systems. This is because the telecommunications developments of recent years focus on communication at a distance and not on the development of the technologies, especially the overhead projector and the whiteboard, which are used extensively in the schoolroom, the tutorial group and the lecture theatre - where technologies are chosen that require the student to travel to the institution for the purposes of instruction.

Educational technology, then, is the field of study that analyses the use of technology in education (Hawkridge 1976). Its findings are directed primarily at schools, colleges and universities, but are of central interest to distance systems as well because of the crucial importance of technology in these systems. Among the differences of focus and of emphasis in the two fields of study are:

* in distance education face-to-face group-based communication is absent either wholly or substantially; educational technology does not abandon interpersonal communication: it nourishes and supports it

* educational technology deals with the use of technology for the education of six hundred million students in the world. distance education does not have this role

* distance education is a form of education in which millions of students are enrolled annually in a vast array of subjects and courses with different enrolment criteria and examination structures. Educational technology does not have these characteristics

* distance education is a form of education, education technology is a field of educational research

* in distance education, the technology is a substitute for the teacher. in educational technology the technology is a supplement to the teacher.

* distance education studies the problems of students who learn at home or at the office, for whom face-to-face group-based communication is entirely, or to a large extent, absent. Educational technology does not in any way abandon face-to-face group-based communication. It does in fact presume face-to-face interaction as the basis for interpretation of the technology

3. THREE GENERATIONS OF TECHNOLOGY

Within the field of distance education research there have been a number of attempts in the literature in recent years (Garrison 1985, Nipper 1989, Bates 1993, 1995) to classify the relationship of technology to distance education and an effort to divide the developments into what are called 'three generations'.

Bates (19945 23) writes:

> The first generation is characterised by the predominant use of a single technology, and lack of direct student interaction with the teacher originating the instruction. Correspondence education is a typical form of first generation distance education.
>
> Second generation distance education is characterised by a deliberate integrated multiple-media approach, with learning materials specifically designed for study at a distance, but with two-way communication still mediated by a third person (a tutor, rather than the originator of the teaching materials). Autonomous distance teaching universities are examples of second generation distance education.
>
> Third generation distance education is based on two-way communications media which allow for direct interaction between the teacher who originates the instruction and the remote student - and often between remote students, either individually or as groups. Third generation technologies result in a much more equal distribution of communication between student and teacher (and also between students).

These generations according to Garrison (1985) are labelled (i) correspondence (ii) teleconferencing (iii) computer-based. Such attempts are to be regarded, at best, as a first sketching of the field, at worst as flawed and potentially misleading. It is not clear, for instance, why the 'teleconferencing generation' should precede the 'computer-based generation' nor whether the 'correspondence generation' and the 'teleconferencing generation' are supposed to have ended before the 'computer-based generation' begins.

In our view it is better to regard the developments in the use of technology in education as a cumulative process in which the benefits of distance education are added to conventional face-to-face provision to bring the enhancement and complementarity that technology can provide. Thus one could see education prior to the introduction of technology in the middle of the 19th century as being always characterized by face-to-face interpersonal communication in the learning group.

If one attempted to analyse educational provision from the point of view of distance education one might identify three differing structures: conventional provision; teaching at a distance; teaching face-to-face at a distance. Each of these complements the others and enriches the possibilities of offering education to learners.

Conventional education

Conventional provision is the normal offering of education in schools, colleges and universities today. Its characteristic structures are the dialogue, the lecture developed by the medieval universities, the tutorial and seminar added by the humanists and, more recently, the laboratory practical, the field trip and the periods of study in the library or resource centre. Its characteristic technologies today are the overhead projector and the white (or black) board, technologies which require the students to travel to the institution for the purposes of learning.

This traditional form of provision can be traced back to the commencement of formal education which historians usually locate in the 5th to 4th centuries BC in Greece. With the developments of technology of the Industrial Revolution this conventional face-to-face interpersonal provision continues, grows more widespread with the growing involvement of almost the whole population in sequential schooling for a substantial number of years (Vertecchi 1993) and is itself enhanced by technology.

Teaching at a distance

The history of teaching at a distance begins 150 years ago. Distance education was not possible without the developments of technology, especially in transportation and communication, associated with the Industrial Revolution. Teaching at a distance is characterised by the separation of teacher and learner and of the learner from the learning group, with the interpersonal face-to-face communication of conventional education being replaced by an apersonal mode of communication mediated by technology.

This form of education is provided today by correspondence schools, open universities and distance or external departments of conventional colleges and universities. Side by side with this traditional provision, and as a complement to it, distance teaching starts to make its contribution from its tentative first steps of the correspondence schools to today's open universities, often enrolling more than a hundred thousand students a year. One could trace the evolution of technology in the history of distance teaching from the correspondence schools of the 1850s to the introduction of educational radio and television in the mid-20th century, to the founding of the open universities in the 1970s.

It is surely significant that the government of the State of North-Rhine Westphalia decided to locate its open university at Hagen as the wire and needle making industries in the valleys of the Hönne, the Ihmertebach, the Oese and the Lenne at towns around Hagen like Hemer, Iserlohn and Altena were the harbingers of the Industrial Revolution from the 1680s onwards. It is an interesting coincidence that the theory of the industrialization of education was developed by Peters who was to become the foundation *Rektor* of the distance university at Hagen.

Teaching face-to-face at a distance

The possibility of teaching face-to-face at a distance was achieved by an electronics revolution in the 1980s. The deregulation of the telecommunications industry allied to the speeding up of chips and the introduction of broadband technologies brought about this veritable revolution. The German scholar, Peters (1993) had argued that there was something unsettling about a form of education (distance education) in which interpersonal communication and face-to-face interaction in the learning group were eliminated, as these were regarded as cultural imperatives for education in East and West. Now these characteristics can be electronically recreated.

Virtual or electronic classrooms can now be linked by satellite or by compressed video codec technology or by full bandwith links, making it possible for the first time in history to teach face-to-face at a distance. The lecturer can see and hear the students present in the class and also all the other students at the other sites hundreds or thousands of kilometres away. All the students at all the locations can see and hear the lecturer and all other students in the system. The interaction of face-to-face education has been recreated electronically.

Teaching at a distance brings great benefits to those citizens who cannot or choose not to attend the schools, colleges or universities of the world but it lacks the interpersonal interaction and, above all, the eye-to-eye contact of conventional education . As the eye is the organ of a person's innermost feeling, argues Peters (1993), this absence of eye-to-eye contact is surely significant. 'We become aware that a whole emotional dimension of the interaction of the teacher and learner is lacking in distance education.'

The 1980s, however, saw developments in electronics telecommunications which may well be seen as just as epoch-making as the achievements of the Industrial Revolution. The introduction of satellite and cable linkings brought undreamed of new dimensions to distance education. These developments are usually associated with the coming together of three factors which together created a climate for outstanding progress:

- an urge of governments to deregulate the telecommunications industry,
- the speeding up of chips and
- the introduction of broadband technologies.

A third phase in the evolution of educational provision may be said to begin with the telecommunications revolution of the 1980s. The introduction of cable and satellite technologies made it possible for the first time in history to teach face-to-face at a distance. In this present phase conventional face-to-face education in schools, colleges and universities continues and is further enhanced by the influence of the new communications techniques. Teaching at a distance, whether from correspondence schools or from corporate training centres or from open universities continues to develop and also benefits from the developments in electronic communications. But side by side with both of these forms of provision , the new dimension of linking teacher and learner by two-way audio and two-way video links has arrived.

As the 21st century approaches, the provision of education to citizens around the world is enriched by the availability of conventional face-to-face teaching in schools, colleges and universities, complemented by correspondence, audio, video and computer technologies from correspondence schools and open universities throughout the world. Both are enriched by the availability of virtual systems in which the face-to-face interpersonal communication of conventional education can be achieved at a distance.

4. DISTANCE SYSTEMS AND VIRTUAL SYSTEMS

At the time of the treaty of Maastricht in the early 1990s most European countries were committed to working to achieve unity in terms of open borders for trading and movement of people. The Research and Development in Advanced Communications Technologies in Europe Programme. has succeeded in defining the general content of broadband communications and the nature of services that could employ 'broadband', i.e. communication channels of 2Mb/s or greater.

It is known that the technology for broadband communications is already here. Through the advances made in the electronics industry, microprocessor processing power is cheap and readily available. Again through the advances in optical fibre technology, the transmission of large quantities of data is no longer a problem. In fact transmission is becoming so cheap that networks could be reconfigured to have less switching. Simultaneously, switching technologies have progressed to the stage where prototype photonic (optical) switches have been operational for a number of years and connectionless type data switching (packet switching) is capable of handling 'broadband' capacities.

The way to the next millennium is chartered with the development of a number of advanced networks and technologies now available such as Asynchronous Transfer Mode (ATM), B-ISDN (Broadband Integrated Services Digital Network) but the development of the services, educational and other, that will exploit these networks is one of the primary issues. This effort must be translated into a full common understanding of the services domain, the distinction between network services and end user applications, and a clear definition of the services architecture.

The way ahead

While the infrastructure technology has advanced, the big question to be posed is - in what way can we use these networks? What communications requirements do we have that need these broadband networks? The answer is multimedia communications, where multimedia means the combination of voice, images (still and moving) and data (usually text or graphics) in a single communication. Multimedia communication is the concept of achieving information transfer at the same level as face-to-face meetings. This can then be applied to many applications such as distance teaching or collaborative document preparation.,

Now the telecomunications industry is faced with the challenge of developing meaningful applications that people will use regularly in the course of their work, education and leisure activities. The task now is to employ these advanced networks and facilities in such a way as to provide applications and services distance educators and other users want, at a cost they can afford, and to ensure service providers and network operators get a suitable return on their investment.

System organisation

The management and control of these services is of great importance. As one starts to investigate services one finds that quality of service, service interaction and a large set of issues must be resolved before a service can be introduced. Then ensuring the correct operation of the services in use will be a requirement of every player in the market.

As distance educators and others start to use the services, the correct operation of these services is critical to continued use and the revenue that will be earned by the service. Service management functions must capture the important parameters for each service and ensure that, for the duration of an interactive session of a particular service type, the minimum rules of those parameters be maintained.

Other aspects of service management include the collection of the necessary charging data, the optimisation of the use of network resources by the complete range of services and the control of interaction between different services.

Distance education as the customer

As the portfolio of network and service offerings increases and the services become more complex, it will be difficult for the educator or other user to understand exactly what service or set of services will satisfy his/her perceived need.

This work will deal with how the distance education customer requirements are captured and processed. It will be necessary to determine what the customer would like (requirements capture), then interpret these wishes in terms of the optimum services set that will support the customer's wishes (requirements analysis). When one has this information it will be necessary to understand what facilities the customer has today (current capability analysis). The final part of this process is to map out an evolution from the customer's current status to the new scenario he has defined (evolution analysis).

One of the obvious consequences of these advanced networks and the high processing power available to users is that the distance education premises networks will become more sophisticated. The interfaces between public and private networks will happen at many levels and will have to support many types of transactions.

A major issue here is how the educator or other customer is allowed to control and configure the resources he has rented from the network provider. If the resources are in the form of leased lines then the customer can only use the facilities - no reconfiguration is possible. If the service the customer is using is a virtual private network, in that the connections are established as electronically controlled semi-permanent connection through digital exchanges, then there is great scope for selling the customer facilities for reconfiguring his network within certain parameters.

Distance education requirements

Accurately to analyse the network requirement of distance education systems, one has to distinguish between services and applications.

Services are facilities inherent in the network that allow users to establish connections on demand, modify the connection type to allow for different bandwidth requirements and have the network handle all the service requests, both to and from the user, in a consistent economic manner.

One can consider 'mobility' as a typical example. 'Mobility' could be considered the next evolution of communication as it introduces the concept of all communications, educational and otherwise, being directed to you regardless of where you are. There are two main themes in the approach to mobility: Universal Mobile Telephony and Universal Personal Telephony

Universal mobile telephony covers the issue of terminal mobility which is associated with radio access networks. This service enables the terminal to roam within the radio access network coverage and the service area defined for each subscription. These service areas may comprise both public and private networks. The radio access may be via cellular mobile radio systems, satellites, telepoint or cordless extensions of the local loop in public or private networks. This means the phone user has one mobile phone which can act as a normal mobile phone as he travels around but can also act as an extension of his company switchboard when he is on company premises. There has, as yet, been little analysis in the distance education literature of the universal mobility by telephone of the distance student.

Personal mobility, is a much wider concept which enables the user to receive services from the network at any fixed or mobile terminal in public or private networks. Personal mobility is independent of subscriber line, terminal equipment and network technologies. However, these must support functions for personal mobility management. Universal personal mobility of the distance student leads the way to the new millenium, with the potential for diversifying distance education didactics away from the teaching of students who travel to schools and universities.

Applications, however, are in the realm of the actual information or processing available from a variety of sources through the network. Although the potential services of the broadband network to distance education is large, the potential for distance education user applications is also enormous.

Everyone has noticed that the world is going digital. Every office or college now has a word processor or personal computer that processes information digitally. Most offices and colleges now have networks that transfer files from one machine to another digitally. Telecommunication networks are becoming digital and as ISDN comes into service they will become totally digital. As digital video emerges, the potential to treat the different media in the same manner will evolve. The concept of amalgamating the media into a single communication form known as multimedia is now well accepted.

Multimedia communication is the beginning of the era of universal communication, where everyone has easy and immediate access to widely distributed information and computing sources in many media including voice, text, data, sound, graphics images and full-motion video, and where people communicate and share information without concern for time, location or medium. Multimedia will help people with their business, education and personal lives and locate and display electronic information as easily as they now use the telephone.

The all-digital approach of multimedia communication merges the technologies of computing, communication and television. The separate business and industry sectors for data processing, telecommunication, television, broadcasting, publishing, photography, video and film will converge to one mega-industry in a universal communication environment. This will be a consequence of the all-digital evolution.

Once signals from phones, television and information services are translated into digital form, they are, technically speaking, identical whether the digital code represents sounds, pictures, words or combinations. That makes it possible to send them all over a single line and even decode them by a single machine, a universal information appliance.

Conclusion

The technologies discussed here are rapidly becoming generally available. This provides for an unprecedented improvement in communications quality, cost/performance and user friendliness. Within the coming decade distance and capacity constraints to communications will be largely overcome, permitting the establishment of an environment where educators and other users can communicate what information they wish to convey, when they wish to convey it, wherever they are, however best suits their needs and with the confidence that the communications are conducted with adequate security and privacy.

The implication for distance education research are great and the potential for the new millenium massive. It would be unfair for distance education researchers and university distance education research institutes to leave the analysis of these telecommunications technologies to on-campus researchers, because they fall squarely within the domain of distance education research (*Fernstudienforschung*). That domain is the study of the didactics of students who refuse to travel or are unable to travel to the schools, colleges and universities that society provides for the purposes of instruction and who insist on being given their university degrees at home.

Distance education and training, because of the nature of its business, has the potential to be one of the leading applications on future high speed networks. But the relationship of electronic systems to distance education has not been addressed by the literature, nor have the sacrifices and dangers that virtual systems present.

Virtual systems based on (electronically) teaching face-to-face at a distance are considered in this monograph as a new and cognate field of study to distance education, a field which already has important realisations like the foundation of the Open University of Catalonia in Barcelona in 1994 as a virtual university rather than an open university and a developing literature like Portway and Lane's *Guide to teleconferencing and distance learning* (1994).

The theoretical analyses of virtual education, however, have not yet been addressed by the literature: Is it a subset of distance education or to be regarded as a separate field of educational endeavour? What are its didactic structures? What is the relationship of its cost effectiveness and of its educational effectiveness to distance education and to conventional education? All that can be attempted here is a presentation of the differing characteristics of distance education and virtual education and a listing of the advantages and the disadvantages of virtual systems.

The differences between distance education and virtual education are perceived as:

> *time synchronous technology* distance education uses mainly time asynchronous technologies; virtual education uses mainly time synchronous technologies
>
> *access* the goal of distance education as enunciated by Wedemeyer (1981) is to provide courses any time, any place, anywhere there are students or only one student;

virtual education reimposes much of the constraints of conventional education by requiring students to travel to virtual classrooms at fixed times on fixed days to join a learning group

economics the basis of distance education economics is that institutions do not have to build and maintain buildings for distance students and that economies of scale can be achieved that are not available to conventional systems; virtual education reimposes much of the economic constraints of conventional systems

didactics the didactic skills required in the electronic classroom reintroduce many of the skills of the school class or university lecture in contrast to the development of learning materials and the skills of teaching from them, often many years later, that is characteristic of distance education.

market the distance education market is, in the main, based on the availablity of educational qualifications by time asynchronous technologies; it has yet to be demonstrated worldwide that there is a market for students travelling to electronic classrooms for synchronous transmissions at scheduled times.

It is acknowledged that in a few years time the videoconferencing window now available on some personal computers will become standard on the motherboard and the experience of compressed video face-to-face synchronous communication will become generally available.

It is too early to suggest whether the study of virtual systems will in the future be studied as a subset of distance education research or of conventional education research or as a field of study in its own right. This monograph considers the study of virtual and electronic classrooms as an important and complex field, still in its beginnings, with a unique contribution to make to educational knowledge.

5. COMPRESSED VIDEO TEACHING: HOW TO DO IT

Terminology

There is considerable confusion in the use of terminology for two-way video, two-way audio codec teaching systems.

Among the terms frequently use are teleconferencing; two-way-audio, two-way-video teleconferencing; videoconferencing and many others.

Teleconferencing is considered to be too vague a term to describe teaching structures based on compressed video systems as it could refer to audioconferences, one-way-video, two-way-audio conferences or computer conferences.

Two-way-audio, two-way-video teleconferences is clear but too cumbersome for frequent use.

Videoconferencing is the term favoured by the important American study *Teleconferencing and distance learning* by Portway and Lane. By this they mean two way interactive video. This term is considered unsatisfactory as it usually refers to business meetings. The focus of this monograph is the analysis of a distance education and training system and this has important differences from conferring or from business transactions. Videotraining' is used here for the use for training purposes of two-way video, two-way audio videoconferencing equipment.

It is acknowledge that videotraining is frequently referred to as 'videoconferencing', the word that is normally chosen for the use of the equipment for business meetings or as 'two-way video, two-way audio training'. It can also be referred to as 'teaching in a virtual classroom' or 'teaching in an electronic classroom'.

For these reasons the term '*videotraining*' is used for this study and the system recommended is referred to as a *videotraining system'*.

An established technology

The first demonstration of personal video communications which led to the videoconferencing of today was the motion video telephone shown at the New York World's Fair in 1964.

Progress was slow until the 1980s when a combination of

- improvements in video compression technology,
- the acceptance of international telecommunications standards for videocompression and
- rapidly falling costs

led to rapid advances in the late 1980s.

Today it is possible to digitize a standard broadcast picture and compress it for transmission over two digital phone lines of 64 kbits per second. This has brought the investment needed for entering videoconferencing down from \$/£1 000 000 in 1980 to between \$/£20 000 and \$/£30 000 today. Desktop systems based on a modification of a desktop computer are available for a few thousand dollars today and will soon be standard on the motherboard.

In this monograph digital telephone lines are referred to as 64 kbits per second. North American readers are requested to substitute 56 kbits per second. The signs \$ and £ are used interchangeably, because it is considered that a piece of equipment that can be bought for \$20.000 in the US or in Australia can be bought for £20.000 in Ireland and the UK.

Here to stay

Successful uses of the technology for training have been achieved since 1988-89, especially in America and Australia, and there can be little doubt that videoconferencing is here to stay. The videoconferencing of business meetings to other national and international sites is already common in companies in many parts of the world.

The \$3 billion US 1993 market for conferencing is forecast to grow to \$13 by 1996, with two-way videoconferencing the fastest growing segment of the market (Portway 1994).

Rapid growth in videoconferencing today is coming from:

- the installation worldwide of ISDN services
- familiarity with the technology from meetings
- fibre optics
- desktop videoconferencing
- videotelephones.

The distance education literature today is reporting growing acceptance of videoconferencing for education and training purposes (Martin and Bramble 1995).

A new skill for lecturers

The implications for education and training of the electronics revolution of the 1980s are now being worked out in virtual and electronic classrooms in many parts of the world.

Two-way audio one-way video systems, satellite delivery, videotraining (two-way video, two-way audio) and desktop videoconferencing are new training delivery systems that are growing in importance. Correctly designed videotraining systems are an excellent way to teach.

The instructor can see and hear all the students in the system and can be seen by and heard by all the students in the system at all times, just as in conventional training. All the students can see and hear the instructor and all the other students in the system and be seen by and heard by the instructor and all the other students, just as in conventional training.

In a well designed system the lecturer can quickly master the technology and can then, with few modifications, teach and interact with the class much as in conventional lecturing Lecturers can quickly adapt to it; the quality and quantity of student learning and retention of learning should be the same as for conventional teaching; costly and disruptive travel is eliminated.

The goal is for the lecturer to be able to present the course as nearly as possible as s/he normally would in a face-to-face situation, and for the technology to become invisible as the content and ideas take precedence. The aim is for the lecturer, with a short period of training, to operate the system single-handedly, without the help of a technician.

Challenges to distance education research

The introduction of two-way video, two-way audio technologies challenges many of the categories that have been established by distance education research. In what follows six differing modes of distance education provision are referred to briefly:

- the home based mode
- the study centre mode
- individual study mode
- group study mode
- synchronous technology mode
- asynchronous technology mode.

From the point of view of the location of the student one can distinguish two modes; the home-based student mode, in which the student studies largely or totally at home, and the study-centre mode in which the student is obliged to travel at varying intervals to a study-centre, equipped and staffed by the school, training institution or university at which the student is enrolled.

A second aspect of the form of education known as distance education is whether the students study individually or in groups. Traditionally, most distance education has treated the student individually, with students coming together on occasion for educational or socialisation purposes either never or optionally or under compulsion, as in the summer schools of the Open University of the United Kingdom. The, introduction of the new technologies we are analysing however, - especially audioconferencing and videoconferencing - has made it possible electronically to teach distance education students in groups.

Two final modes of distance education can be distinguished: the asynchronous mode and the synchronous mode. Traditionally, the use of technology in distance education was asynchronous, that is the communications in the system between teacher and student, student to teacher and student to student were sequential and there was a lapse of time, often quite considerable, between the various attempts to communicate. The introduction of the technologies we have been analysing, however, - especially audioconferencing, videoconferencing and computerconferencing - has made synchronous communication possible, as teacher and students or students with other students can be grouped electronically at a distance.

Wedemeyer (1981) had always argued that a distance education course should 'be available any time, anywhere there are students or only one student'. This is a maxim that has served distance education well over the last generation. As a result most distance systems at the end of the millenium favour a home-based, individual-based mode using asynchronous technologies. The challenge to distance education research posed by these new electronic telecommunication technologies is that, at present, they proposed a sharply different mode: travel-to-a-centre-based, group-based, using synchronous technologies.

6. COMPRESSED VIDEO TEACHING: SUCCESSFUL EXPERIENCES

If videotraining is to be an accepted distance education technology for the new millennium, it is essential that there should be well known examples of successful student learning from the technology already documented in the literature. Some brief examples of successful, and not so successful use, are given in this section from Australia, the US, the UK and Norway.

Evidence from Australia

Latchem (1995) from Curtain University of Technology in Perth gave a major presentation of the 'two-way video and audio-compressed digital videoconferencing Tanami Network owned and operated by Aboriginal communities in Australia's "red heart"' in the volume *Open and distance learning today* prepared for the 1995 world distance education conference in Birmingham, UK.

At Curtain University the system is not used for programmed teaching but extensively used across Australia for meetings. Curtain have had some excellent teaching experiences with it especially a Masters course in Business Studies where the students were put in contact with Singapore Polytechnic for simulations, negotiations and experience of Asian marketing techniques.

Curtain have also used it with success for classes to remote students in Western Australia but the demand in Australian distance education is for time asynchronous communication. This means that remote students wish to study at their own time, rather than be programmed to attend videoconferencing classes. Videoconferencing is used mainly in Australia for inter-campus teaching (as at the University of Ulster).

The cost is $400 an hour for 128k anywhere in the world. Rates within Australia are standard ISDN rates and are regarded as competitive for business meetings e.g. $68 per hour from Perth to Melbourne. They use Picture Tel which they regard as the most reliable and user-friendly. It can go to 384k but now that the seeding funding from the government department DEET is gone transmission costs are central.. An A & T desktop system can be bought in Australia for $8,000.. They are confident that it can be widely used and cite their use to Singapore, saying it was excellent for role playing, negotiations, simulations, professional development.

Videoconferencing works, they say, where it is integrated into good distance teaching and learning, is interactive and participative. The physical location of the clients and what they are used to in educational technology is crucial.

By 1988 the South Australian Institute of Vocational Education, then the Adelaide College of Technical and Further Education, had established a frequently used videotraining system. and it remains in frequent use today. The state of South Australia is 1 million k^2 and has little population outside the capital. There is a network of Institutes of Vocational Education throughout the state and these are linked by videoconferencing.

There is fibre optic cable laid all over the state and they are using 2 x 128 kbps line through a government network in which they have dedicated 24 hour per day lines. The original system was custom built 8 years ago in a normal size classroom with four very large TV screens (quadrasplit automatically when one of the remote sites spoke) behind the lecturer and two very large TV screen at the far end of the classroom so that the lecturer could lecture to the students at the two remote sites. There was usually a full class at the home site. They had 2 mbit lines with excellent echo cancellers and vision splitters. Today they use PictureTel equipment with CLI codecs and 2 x 128 k lines. It is claimed that the new system is a bit grainy and does not support as much movement as the old system.

The main use has been for practical hands-on subjects like Business Studies, Wine Industry training, Horticulture, Hospitality Industry training rather than academic courses. It is reported to be very useful for tutorials and subjects with plenty of interaction and discussion.

Evidence from the United States

Portway and Lane's (1994) *Teleconferencing and distance learning* gives an in-depth analysis of the use of two-way video systems in the US today for both business and educational purposes. They show that videoconferencing is the fastest growing segment of the electronic telecommunications market in the US and cite extensive examples of educational use.

The University of New Mexico at Albuquerque In the fall semester of 1995 will have 3 courses on it of 48 hours each in 3 to 4 hour blocks. They do not have enough student sites and the system will only be used a couple of times a week for teaching purposes. 112k costs are 16 cents a minute anywhere in the State, i.e. 8c per minute per line, which is by special contract with their network supplier. There are other costs-they bring in a TI line which they can divide into channels and this costs $400 per month and the remote sites have to pay an access fee of $600 per month .

They are using a CLI Eclipse 2 which gives up to 384k. It is a one screen unit and costs $35,000 including the camera. They do not find any real constraint on course content. At New Mexico, however, it is the medical and nursing faculties that have become involved, using it mainly for smaller MA and graduate courses of a seminar nature. For lecturing to 80 students in other courses they use their one-way video, two-way audio satellite system.

The Florida Teletraining Project provided 422 hours of course content transmission by compressed video with other on-site training activities. Five courses were provided with three of the courses lasting 2 weeks and the other two lasting one day. Student numbers varied from 26 to 116 per course. The one day courses are listed as 7 hours; the longest two-week course lasted 116 hours. Student achievement is rated as very high by well-controlled statistical analysis (Martin 1993. Bramble and Martin 1995).

Martin (1993:65) describes the system:

> The methods and media produced for this project were designed to be appropriate for video teletraining. Teletraining is a distance education technology system, that is, taken as a whole, it is a sophisticated audio-visual package. For example, it uses a two screen system thaat can use any combination of live presentation , video segments, prepared graphics, 3-D objects, slides and computer animation. In addition computer graphics can be displayed as instruction is occurring to make a specific

point. Graphics can be generated by the multi-media computer or projected over the Elmo (a graphics stand with a camera.

This was a heavily funded US military programme to assess the value of videotraining for US military trainees both at officer and enlisted personnel levels. The project used VTEL two-screen videoconferencing equipment with CLI REMBRANDT II codecs, an Elmo graphics camera, Ku band satellite transmissions and a digital transmission rate of 224 kbps. The instructor was located in a Community College in Florida and the students were at military training centres in Florida, Georgia and Maine.

Evidence from the United Kingdom

The University of Wales is a university on four sites at Cardiff, Swansea, Aberystwyth and Bangor, with Bangor being the most isolated. Videoconferencing is being used by the Bangor site but not as much as the southern sites (Cardiff, Swansea). Transmissions from Bangor average once every two to three weeks for teaching purposes. Since it was set up 5 years ago it has been used steadily for teaching, but some lecturers are still a bit apprehensive about using it. It is very much used for meetings because of the isolated location of Bangor from Cardiff.

Prior to a recent upgrade they had a dedicated fibre optic link which gave them 1 Mbit for teaching. This was excellent, but they were renting the line whether they used it or not and now they are only paying for the calls. The change was made to save money and to allow them to interface with other systems but they have ended up with a weaker system. The system is and was the standard BT VC 7000 teleconferencing system. This means that in a standard size classroom there is a heavy wooden cabinet with dual screens, a master control panel, a remote control pad, and octagonal table at which the lecturer (or the academics attending the meeting with Cardiff) sits, seating for about 20 students, two suspended mics and two large monitors for the students to study. The new changes are in the software, and mean transmission at 384k within Wales, 128k outside Wales and the 2 Mbit stream of the SuperJanet link defaults to 384k when they receive it.

They claim that any standard lecture can go out over the system, including writing on acetate on the OH camera, writing on the whiteboard (not at the Bangor site). It is a four camera system with one on the audience. The cameras are very good, allowing movement while lecturing. One hour is said to be the right duration for lectures and it is considered unlikely that students would sit there for more than 2 hours.

The University of London (UCL) has its own network running on SuperJanet which is used for 500 hours per year for meetings and teaching. It has a second network on 384k ISDN which is used for teaching purposes for 300 hours per year and a third called Livenet, developed in 1985, which has been discontinued. Costs are minimal on the Superjanet which is the UK university digital data service pipe from which they get 2Mbit links. As the 384k ISDN network is within various colleges in London costs are again low - between £15 and £20 per hour.

Livenet was 6 miles of fibre optic cable around London which gave excellent results as they put 3 top quality cameras on it. Many British security systems are based on it today. The SuperJanet system links 18 British universities for videoconferencing with the University of London as one of the major players. SuperJanet supports a video network based on 2 Mbps permanent virtual circuits. For the ISDN system a 384k link was chosen over the 128k as 128k is regarded as inadequate for teaching purposes.

The Superjanet system has been used extensively each year for many years for teaching of surgery and medicine to students in lecture rooms with large screens at the remote sites. Other important faculty users are Computer Science, Physics and Biological Science, with Dentistry next in line. The basic medium is the 1 or 2 hour lecture with practical demonstrations of surgical or other techniques. The ISDN network is used extensively for History, Physics, Wave Science to various campuses of the university.

UCL insist on a trial period to get the protocols right before a contract is accepted. 384k is the minimum acceptable for teaching. The complexity of the environment for teaching is much different from business meetings. With complex audio and video problems especially the control of audio at remote sites in multi-point teaching (they often have 6 medical schools attending a surgery lecture together).

They are working on projects such as how to teach on a network, how to promote interaction, how to promote student satisfaction, the psychology of videotraining, videotraining lecture techniques, more effective use of the technology., Videotraining will not fade away, they claimed, as desktop videoconferencing will become universally available with the result that videotraining will become a standard option for education and training.

Evidence from Norway

Researchers in Norway claimed that it was 'difficult to get accurate information because people do not really evaluate their enthusiasms scientifically and most of those involved in videoconferencing want to promote it'. Videoconferencing studios had been installed all over Norway in the early 1990s and are being used less and less. The 2 Mbit connections were too expensive for schools and colleges when the seeding funding was withdrawn.

When the two-way video studios were established all over Norway the distance education colleges used them with enthusiasm for training purposes. That was in spite of the problem of getting paying distance education students, who were used to stying by correspondence at home, to travel to them. It is said that when the authorities made the colleges pay for their use from 1993 onwards usage virtually stopped.

The original installations were 2 Mbit lines which gave excellent results. They are now experimenting with videotelephones over 128k ISDN for teaching groups of 15-20 to give psychological and counselling support in schools and also used 64k videophones for tutoring. The original network of centres was used extensively for adult training.

7. COMPRESSED VIDEO TEACHING: TECHNOLOGICAL CONSIDERATIONS

A basic system

A basic videoconferencing system consists of:

- a video camera
- a codec
- a TV monitor
- a microphone

at two or more sites.

The codec, short for coder-decoder, converts the analog video and audio signals picked up by the camera(s) and microphone(s) into digital form and then compresses them for transmission down the phone line. At the receiving site(s) the signals are recomposed into analog video and audio again.

Compressing a digital video signal is more a process of elimination than squeezing. Compression is achieved by eliminating all data unnecessary to achieving a transmitted image of acceptable quality. Video is transmitted frame by frame, with each frame corresponding to a still picture. Each succeeding picture changes as motion takes place. Data that does not change between frames need not be transmitted with each frame.

The compression process is therefore a matter of selecting only that data within a picture that must be transmitted with each frame to maintain an accurate image. In this way modern codecs can cope quite efficiently with a correctly-dressed instructor seated at a desk delivering a course. The same instructor dressed in a striped jacket and walking through a crowded supermarket would, however, cause problems and probably result at an unacceptably jerky picture at the receiving end because the richness of the data to be transmitted from frame to frame is too much for the codec to eliminate.

Commercially available equipment

Many of the videotraining systems in successful use in the world today have been purpose-built at considerable expense. The challenge today is to show that commercially available videoconferencing equipment, designed for business meetings, could be used successfully for training purposes in such a way that exactly the same levels of student achievement would be accomplished, as in the same course taught conventionally to students face-to-face in terms of: learning of course content; retention of course content; application of course content to the work situation; examination success; award of certificates.

A further challenge is that no expensive modifications to the equipment provided should be recommended as the aim is to use a commercially available business-meeting product for training. Because videotraining is a new technology first impressions of both students and lecturers are most important so that they become supporters of the systems. It is essential, therefore, that excellence in vision transmitted, excellence in audio transmitted, and excellence in didactic structures transmitted be the standard.

Technical considerations

Although it is difficult to generalize because prices, configurations and upgradings are in a constant state of change in a rapidly developing technology, it can be said that major providers (CLI, Picturetel, VTEL and many others) sell a basic model in the $20.000/£20.000 price range, a medium level model in the $40.000/£40.000 price range and an advanced level at about $75.000/£75.000.

It should be possible to teach from a $/£ 20.000 machine to students in front of a similar machine at six ISDN lines (384 kbps or 336 kbps) anywhere in the world that such facilities are available.

Brooksby (1994:59) gives this analysis from an American perspective:

> Video codecs today range in price from $20,000 to $85.000. The bottom data rate is holding constant at 56 kbps. There is not much pressure to get below 56 kbps for group face-

to-face meetings because digital network costs are close to that of a normal phone call. A full T-1 connection in today's market will cost about $50 per hour. This has allowed the codec manufacturers to focus on improved picture quality at 384 kbps or above.

Transmission rates

On the assumption that an 8 KHz analogue video might be about 256 Mbps in a digital bitstream, one can recommend these values for present transmission rates:

2 Mbps	Inferior to Betacam About VHS quality Excellent for teaching Excellent for meetings
384 kbps	Much inferior to VHS Acceptable for teaching Good for meetings
128 kbps	Acceptable for meetings Too jerky and too poor lip sync for teaching
64 kbps	Hand held videophone.

It is clear, therefore, that videotraining places many more demands on the technology than the business meeting does. The reasons for this are:

- the codec must transmit and recompose normal teaching movements perfectly, if students at the remote site are not to be frustrated and lose confidence in the technology

- students need to be able to follow a lecture closely for the best part of a day or for many days - this is normally much longer than a business meeting

- lip synchronization must be perfect, otherwise students will have difficulties taking notes and following the lecture

- the audio must be perfect and all howlaround and echo eliminated - if the video is poor, the lecture can continue; if the audio is poor the lecture has to be stopped

- genlocking of cameras is required to avoid a disturbing flash at the remote site as overheads are changed or cameras switched from overhead to the lecturer

- much superior lighting is required to assure an adequate signal to noise ratio for teaching, and it needs to fall on the face of the lecturer

- the lines must not fall during the class and hits on the lines need to be reduced to a minimum.

8. COMPRESSED VIDEO TEACHING: DIDACTIC STRATEGIES

In this final section a series of hands-on suggestions are presented to assist readers in the design of their system. The focus of this design is on quality of lecturing. Many systems in use today give the lecturer a series of controls to manipulate while teaching.

It is felt here that this is unnecessary and that a user-friendly system can be designed in which there is only one control (switching from the overhead camera for graphics to the lecturer and back again) so that the lecturer can concentrate on lecturing to the remote students and the technology becomes invisible. The system is technician-free and it is anticipate that, with little training, the lecturer can manage it in most circumstances.

1. The system should always be set up some days in advance by a competent videoconferencing technician. Most systems have complex dialling protocols, especially when calling outside the country.

2. In the system recommended here the camera is routed through the overhead camera and genlocked to it and both cameras are fixed before the class commences. In this way the instructor has complete control over the system by depressing one button. By pressing button 1 the lecturer shows him/herself to the students at the remote site; by depressing button 2 the graphics are shown to the remote site and the lecturer can relax because he/she is not on camera but can observe the concentration of the students at the remote site on the screen in front of him/her. All the concentration of the lecturer can thus be given to presentation of the course, in contrast to most other systems in which complex controls have to be used by the instructor while teaching:

3 The clock is placed on the wall of the conference room so that when the instructor looks at the clock the students at the remote site think he/she is looking at them.

4. The videoconferencing machine with its camera is positioned 2 to 3m from the instructor when seated. This distance has been calculated to give at the remote site the

impression of a lecturer teaching interactively and with immediacy. A part of the desk, of the lecturer's notes and of the overhead camera are visible at the remote site, thus creating an educational context. If one positions the lecturer closer to the machine one gets the impression of a TV newsreader and not an educational context. If one places the camera further out, one gets the impression at the remote site of a distant presentation, lacking immediacy and inducing boredom and lack of focus in the students at the remote site.

5 The desk is kept completely clear of equipment so that the instructor can concentrate fully on the learning of the students at the remote site. The desk is large and spacious giving plenty of room for the instructor's notes and for the instructor to relax when presenting the course.

6. To the right of the presenter is the overhead camera. for the transmission of 3D objects, graphics, slides, transparencies or pages of books.

7. Behind the lecturer is a white board which is angled slightly downwards so that it does not throw back light into the lens of the camera.

8. The instructor's chair in the system proposed is fixed as it must remain throughout at a fixed distance both from the lens of the camera and from the whiteboard.

9. Off-camera the instructor has the control pad for dialling and hanging up the call, and a telephone for calling the remote site or the videoconferencing technician in case of emergencies.

10. Outside the conference room the lecturer has a fax machine for sending additional material to the students, for receiving their assignments and other exercises and for returning corrected work to the students.

11. The lecturer must not go outside the range of focus of the camera - if s/he does the effect would be a bit like hearing the lecturer's voice teaching after the lecturer has walked out of the room.

12. Within the teaching space lecturers can act as they would normally when teaching, except for swift, jerky movements.

13. A major skill to be learned is how to make eye to eye contact with the remote students. It is essential to maintain eye contact with the camera lens at all times, except when transmitting the OHC. This is a skill all TV newsreaders and presenters have to learn.

14. If you do not maintain eye contact with the lens of the camera the effect that the students get is that of an instructor looking at a picture on the wall or looking out of the window while teaching them.

15. Throughout the lecturer has to ensure that the students maintain eye-to-eye contact with him/her, that is they focus on the lens of their camera.

16. Lecturers should use their normal speaking/teaching voice. and not shout.

17. Lecturers need to remember what the technology can't do, and plan in advance how they are going to compensate for it. They can't wander around,or spend a few minutes with each,.
their contribution; give them a diagnostic test.

18. It is important that students are not immobilized by not knowing the protocols of interaction. The lecturer needs to explain at the start whether they can interrupt from a distant site or not.

19. Lecturers should number each handout or sheet on the OHC as they are not at the student site to supervise their use

20. It is important to speak clearly and distinctly and slightly more slowly than normal

21. Lecturers should wear solid, contrasting colours that complement the decor of the electronic classroom but do not merge into it. They should not wear tweeds, heavy stripes, polka dots or brilliant whites.which shimmer at the students' end.

22. The OHC is a versatile didactic tool and has a much greater range than the OHP lecturers will be used to. It can take overheads, a page of a book, an object, a small piece of equipment

and many more pieces of information that one may wish to transmit.

23. Videotapes can be played through the OHC or through most videoconferencing machines.

24. Visuals for videoconferencing should be prepared on paper, or preferably, light card and not on transparencies which shimmer at the remote site.

25. Landscape format not portrait has to be used

26. Videoconferencing visuals must be 4 x 3 like a TV screen

27. Light yellow or blue paper or card looks well at the other end. White paper looks a light grey.

28. All writing on videoconferencing visuals need to use 24 point or greater to be read at the remote site.

29. The maximum number of characters in a line that can be read at the remote site is 27.

30. The maximum number of words one can use in a videoconferencing graphic is 30:

31. Lecturers need to mention homework, exams, certificates and the importance of interactivity in the learning process from the start.

Summary

The hands-on advice given here on the didactic strategies to use in a videoconference system are chosen to be user-friendly, cost-effective and designed to promote interactive and effective learning, on a par with the teaching of the same course by the same lecturer in a conventional setting.

The system described gives the lecturer five differing didactic strategies and careful preparation to blend and vary the strategies during the course should achieve effective presentation. The strategies used are (1) for the lecturer to be sitting addressing the camera lens (ii) using the overhead camera, a strategy most will be familiar with, (iii) standing addressing the camera lens, (iv) working at the white board (v) dealing with questions, answers and discussions with students at the remote site.

It is appreciated that other strategies may be used in other settings. Three other settings may be mentioned briefly:

- large, custom-built systems which often have a variety of controls for the lecturer to use

- desktop systems in which the lecturer teaches students at the remote site from an office-based system

- complex graphic packages and computer-conferencing facilities in which students and lecturer can work interactively on, for instance, a spreadsheet. It is felt that at the time of writing these systems are mainly proprietary to a particular manufacturer and can only be used when transmitting to the same machine at a remote site.

In all systems there are three central aspects for students in videotraining:systems: personal interest in seeing the face, reactions and personality of the instructor; illustrations, overheads, slides, videotapes and 3D objects seen via the system; key phrases and summaries displayed to anchor attention and to remain in memory.

The challenge is to design cost-effective and educationally-effective systems for the use in the new millenium of the new technologies that permit for the first time in history the (electronic) teaching of students face-to-face at a distance.

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