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ABSTRACT

This paper describes a project conducted in 1991-92, based on research conducted in 1986-87 that demonstrated the need for a telecommunications system with the capacity of integrated services digital networks (ISDN) that would allow for sound, vision, and integrated computer services. Called the Tri-Centre Project, it set out to explore, from the point of view of the Telecom Corporation of New Zealand and three educational institutions, how an educational ISDN can be set up in New Zealand and the critical issues that need to be addressed to implement educational ISDN to advance the educational system of New Zealand. The project generated great interest, forming the basis for the Network College of Communication in the Pacific which was initiated with the University of Hawaii and the East-West Centre. This paper describes the project and the various types of technology used to conduct a "virtual class." It also discusses learning theory and predicts the future of educational technology use. It contains 31 references. (Author/KC)

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THE RESEARCH PATH TO THE VIRTUAL CLASS

Zentrales Institut für Fernstudienforschung
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CONTENTS

Abstract

This monograph places in perspective the research in distance education which I began in 1986. My seminal research made the case that there is likely to be a strong correlation between the growth of distance education and the developments in new communications technologies. I pointed to a massive expansion of tertiary education opportunities and the decline of postal services that underpin correspondence-based education and the consequent need for a telecommunications system with the capacity of integrated services digital networks (ISDN) which will allow for sound, vision and integrated computer services. Using a case study of the largest single education institution in New Zealand, I developed two scenarios which examined the movement from a correspondence-based institution designed for the industrial society to that of a multimedia based one designed for an information society of 2001. The scenarios developed have proved to be valid. In 1987 we developed the first cycle of our research which we called the Golden Application Project and argued that education could prove to be ISDN's golden application.

Given that in the next millennium we can expect to see a major transformation of education as a result of sophisticated telecommunications networks, John Tiffin and I in the Department of Communications Studies, Victoria University of Wellington, New Zealand, began the second phase of our research which we called the Tri-centre Project. We set out to explore, from the point of view of the Telecom Corporation of New Zealand and three educational institutions, how an educational ISDN can be set up in New Zealand and the critical issues that need to be addressed to implement educational ISDN to advance the educational system of New Zealand. This Project was evaluated and generated great interest in the University, nationally and internationally and formed the basis for the Network College of Communication in the Pacific which was initiated with the University of Hawaii and the East-West Centre. Furthermore, in 1993 my research was the basis of the Scoping Report for the Department of Prime Minister and Cabinet titled *The Use of Telecommunication Technologies for the Enhancement of Educational Services*, it underpinned educational policy in this country and also educational policy for rural Maori development.

In 1995 John Tiffin and I co-authored the book *In Search of the Virtual Class: Education in an Information Society*. Our action research on the impact of information technology on education as a communication system continues to the end of this century.

INTRODUCTION

We began a programme of research in 1986 that we called the "Search for the Virtual Class" to design the kind of learning system that will be needed in the broadband digital telecommunications environment that will exist in an information society. This environment will allow access to education to anyone, from anywhere, at any time and in any mode of their choice.

By a virtual class was meant a virtual place where teachers and learners could meet as tele-presences, synchronously and asynchronously. We had in mind that it would have at least the same multimedia capability as a conventional classroom. Everybody should be able to see and hear each other clearly and whatever was being taught. This meant a blackboard, whiteboard, projection screen capability for interactive use of text and graphics and for moving images. We thought this could be feasible in 2000, and decided to conduct iterative cycles of research over a period of 15 years. During that time we believed that telecommunications technology would be evolving in the direction of broadband ISDN. We wanted a matching evolution of instructional methodology.

So far there have been three cycles of development. The research, since its inception has had the support of the Telecom Corporation of New Zealand and in 1992 it also counted on support from the Australia Telecommunication Corporation. Each cycle of the action research took the form of designing a telelearning system which in some way sought to emulate an ISDN environment and implementing it with mature students doing a graduate diploma in Communications Studies at Victoria University in Wellington, New Zealand. In the manner of action research of this nature we envisaged that at the end of each cycle there would be an evaluation and discussions with stake-holders and developments in information technology that would lead to changes in our designs and the way we implemented them.

The first cycle began in 1987 with a project called the Golden Application Project developed on the basis that education was the golden application for the developing ISDN-based information technology. This was based on my published doctoral research in 1988 and looked at the impact of new communications technologies on distance education.

All the 18 students involved were given a telephone line, access to Starnet and a computer-phone which we believed reflected the interface of the future. We used the system for course administration, assignments and examinations. The student response was positive. They spoke of the system as convenient and liberating. The way they could sit down, type out an assignment, send it and sometimes have it marked and back to them within the hour they found a big improvement on the normal feedback pattern. One student thought he would have to miss the final examinations because he had to travel from New Zealand to Tipperary for a funeral. He was, however, able to do the exam by phone. He used the office of a company who, when they saw what he was doing, offered him a job on the spot.

In 1989-1990 we designed a more ambitious programme for the next cycle. Support from Ameritech enabled audio-conferencing and video-conferencing links between Victoria University and Ohio State University for joint seminars in a course on international communications. Teachers and students had personal computers, a telephone headset and were provided with two telephone lines in addition to the one they already had in their homes. The idea was to emulate narrowband ISDN with its three channels. The students had access to BITNET so they could communicate with their colleagues at Ohio State and the course had its own network which allowed for e-mail and for teleconferencing with audio and data system for teletutorials.

We moved too far and too fast. Added to this the BITNET connections were frustrating to use. When we tried to videoconference between the two universities a transponder in the link carrying the video signal from Ohio to Wellington was pirated.

The students became frustrated. Problems in intercultural communication emerged. The American students saw themselves as pioneers; the New Zealand students as Indians. The networks set up for instructional purposes were used for gripes and became battlefields for flame wars.

The successful element in this cycle was the teletutorial system. This linked three or four students and academics in their homes and offices. Each member of the tutorial would sit in front of their computer with a telephone headset on. A student would present an assignment and everybody would be able to read the text simultaneously. The tutor could scroll through the text, or highlight it with a cursor while everybody discussed what they were looking at. This permitted a focussed debate. The instructional process was reduced to basic elements; the text under discussion was directly in front of the eyes with minimal visual distraction and the earphones cut out distracting sound. Missing too, was the social self consciousness that goes with face-to-face tutorials.

The third cycle ran from 1991 to 1992. It was known as the Tri-Centre Project because it linked three telelearning centres, two of which were set up for teachers at a school and for teachers at a remote rural Polytechnic, and at the Communications Department at Victoria University. It was a response to a real problem. Because of problems of space and time the people in the remote centres could not make classes at the University.

The media combination used was E-mail, fax and audiographic teleconferencing. From the lessons learned in the second cycle, fail safe systems were built in. For example, all seminars at Victoria University were videoed and copies of the videos were distributed to the remote centres. This seemed to give them a special advantage. Unlike the students who attended class conventionally at the University, they used the videos for review and found by doing this they had better understanding of the issues raised in the seminar.

The audiographic conference system used in 1991 was developed with financing from Telecom New Zealand on the basis of our designs. It worked well and gave some indication of what could be possible if telecommunications technology was designed on the basis of the needs of learners and teachers, as distinct from what software designers think they need. The system was intuitive and user friendly. However, it proved impossible to continue with the development and in 1992 with support from Australia Telecom we used what is now known as the Vis-a-Vis system. It had all the facilities such as audiographic conferencing and slowscan video images we needed for our pilot project, including many of the updates we wanted. The technology was beginning to catch up.

By 1992 the system was working well and an independent evaluation of the Project established that the remote students were satisfied that the system was giving them an education that they would not otherwise have been able to have and that there was no significant difference between their learning and that of the conventional students. By this time another outcome of 'the search' had born fruit. With Stan Harms, at the University of Hawaii and Syed Rahim, of the East-West Centre, we had established the Network College of Communications in the Pacific, initially an organisation of six universities and four research institutes concerned with telelearning at the international level. It envisaged the interlinking of national telelearning networks with international networks. We put this into effect by linking our national network with the University of Hawaii for audiographic seminars for a period of eight weeks and on one occasion we succeeded in linking all members of the NCCP together for an audioconference.

By contrast to the experiment with Ohio State, student response was positive. They spoke of a *richness* in the learning experience that came from looking at topics from many aspects. Authorities from around the world would join us in our teleseminars and there were two sets of student and teachers from different cultures.

This time the system worked. The players knew it and said so. What made the difference? From a technical point of view we had built in the kind of redundancy that exists in conventional classroom education. We used two lines, one for audio and one for graphics. If the audio signal was not clear it was still possible to follow the sense of what someone was saying from the way an argument was built up from diagrams and key words and bullets on the graphic system. In case the line carrying the graphics went down all pre-prepared graphics were faxed to the different centres before a seminar.

The international links worked because there was a heightened awareness of intercultural sensitivities. Initially, we were concerned to see signs of a re-emergence of problems in intercultural communication. There was a point at which the link between New Zealand and Hawaii hovered on the edge of catastrophe. The New Zealand students were looking forward to a good argument with their Hawaiian counterparts. The idea horrified the mainly Asian students at Hawaii. They wanted to know exactly what would be said so that they would be prepared. The New Zealand students could not see the point of conferencing if everything was predetermined. In the end one student representative from each group sat on a long-distance telephone call until they achieved a compromise. This proved successful and the two sides began to see the value of each other's point of view. From then on relations between the two groups were excellent.

The success of the third cycle prompted us to design for the Telecommunications Corporation of New Zealand a national telelearning network that is available for any instructional system, private or public, training or education, kindergarten or university and this has been successfully developed and used since 1993. Another outcome has been the adoption of the teleconferencing system by the Maori of New Zealand to link rural Maori communities for education and access to information and to link with native peoples in other countries.

However, the new information technologies do not as yet seriously rival those of the classroom. The superhighways are not in place. The information society is still a vision. The technology is still in flux. We are just beginning to address the question of multimedia and database access in education. To add to this a new information technology is looming over the horizon which may well shift the whole direction of education. It is virtual reality.

So back to the drawing board. In October 1993 we helped Asia University in Tokyo launch its new ISDN teleconferencing centre with inaugural telelectures and teleseminars. Our concern for the next cycle is to design a system that explores the possibilities of ISDN for international telelearning. But it is the cycle after that we are really looking forward to as we work with Asia University and the Advanced Telecommunications Research Communications Laboratories in Kyoto on the design of a joint virtual teleseminar system between Asia University and Victoria University for the year 2000.

The third cycle of our research embodied in our book *In Search of the Virtual Class: Education in an Information Society,* argues that as information technology impacts all sectors of society, it will change the way we work, shop, play, live and learn. The educational environment as we know it today, how we provide and organise education, and how we learn is changing dramatically to keep pace with new realities and learning needs of societies. We envision an ideal learning space we called the virtual class. This is a place that exists in computer-generated reality. Given the rapid advances in information technology such as multimedia teleconferencing, the Internet, virtual reality and hyper-reality, what shape will education take in the future? What will replace the classroom as the focus of instruction in the information society?

In our book, we examine the question whether the worldwide demand for more education can be matched by an expansion of existing classroom-based educational systems. Even the rich nations face the growing costs of classroom education, while the poorer nations find themselves in a losing battle, unable to expand what classroom education they do have to match the rate of growth of their populations and the demand for education. We describe the evolution of an alternative, a complement to the conventional classroom as the primary locus of learning - the virtual class.

Vision in education is always of the past. This monograph looks at the conventional classroom and traditional distance education and examines how audioconferencing audiographic conferencing, videoconferencing, multimedia conferencing, the Internet and the World Wide Web are steps along the way towards the powerful distributed virtual realities that can improve learning environments for the information society. The following scenario based on our book gives a glimpse of the virtual class.

LEARNER 2000

In her home in China, Learner 2000 zips herself into a skin tight suit (which has inbuilt sensors that are connected to a computer). Next, she sits astride on something that looks like a bicycle which has no wheels but is firmly anchored to the floor. Her feet fit onto something like a brake and accelerator and her gloved hands hold on to a handlebar that has a few controls. She dons a helmet and is no longer in the real world of her real home. She is in the virtual world of her virtual university.

As the helmet closes over her head she finds herself looking at an information map of the university which shows her all the courses offered and their pre-requisites and all activities she is likely to need. There is her individual diary of daily activities, class timetables and academic calendar. Just with a fractal turn of her head she can find out when the classes are, where and how long they are; also when assignments are due and monitor her progress. Library, registry counselling room, classroom, computer rooms and labs are all clearly marked. To go to any one of them all she has to do is to reach forward and "touch" them and she will be there. Today she is leading a session on the rain forests in Brazil. She is not sure if she has grasped some of the concepts involved. Putting timetable on automatic, which means that when a class begins she will automatically find herself in the class, she hits the library function and selects the terra forming and flight overview options. As the simulation forms around her she gets the familiar feelings of butterflies in her stomach as she finds herself hovering 1000 feet above the rain forests. She reaches for the reassuring touch of the handlebars and kicking the accelerator zooms down into the barren land that had been denuded. She touches a function key that gives her the simulations capabilities and selects the forest as it was at a century per second starting 1000 BC. She was startled to find the rapidity with which the forest had been denuded in the last 30 years. By slowing the simulation down she could study every aspect of erosion and the effects it was having. Suddenly, the rain forests disappear and is replaced by a three dimensional image of her teachers and classmates sitting in a glade in the Lake District among Wordsworth's dancing daffodils that they had designed. Yes, the virtual class is starting!

Just how feasible is this scenario? Technologically everything that is described will be available within the next ten years. A child born in the nineties could be educated in this way. A datasuit of any real sophistication with force - feedback that gives a sense of touch, presupposes some rather rapid developments in this area. There is a basic assumption that computer performance and memory will continue the present trends towards greater memory, faster processing and miniaturisation and that broadband telecommunications technologies will become widely available. Looking at individualised speech recognition systems that exist today it is difficult not to imagine that they will become the basic way of communicating with personal computers in the near future. The wheel-less motorcycle device is simply one of many designs for an interface system that allows a person to feel secure and comfortable in adjusting to the physical discrepancy between what bodies do in the real world and what minds do in reacting to virtual worlds. If the equipment and the software were mass produced for a global school population they would surely be cheaper than the buses, roads, schools, books etc which constitute the infrastructure of conventional classroom education.

Learner 2000 attends her virtual school from her home. She could as easily attend from a local community centre or conventional school. The scenario indulged in a high tech version of the interface equipment needed for a virtual school. A simpler system could be little more than a pair of spectacles and gloves. With cellular telecommunications it would be possible to join a virtual school anywhere in the world.

THE VISION

The essence of the vision is that the educational system for an information society will be distance independent. And if that is truly the case then it could also be independent of a particular country. Education could become an international as well as, or perhaps even instead of, a national service. The student may not have to attend class with people who come together simply because they live in the same area. Instead it will be possible to share class activities with people who share the same interest in a subject even though they may live at the opposite ends of the world.

Besides liberating education from limitations of space, many time restrictions could also disappear. An instructional ideal is for people to learn at their own pace. The concept of a virtual learning environment brings this closer. Asynchronous instructional activities such as reading, doing exercises and individual assignments and accessing knowledge bases need not be dependent on institutions being open at fixed times. When there is no need for teachers and students to go to a physical location for education, the need to conduct education in lock-step and in fixed time slots is reduced. Students and teachers can keep flexible hours and calendars. Every student can have their own schedule and a virtual school could be open every hour of every day. The students and their teachers could be spread around the world.

The scenario suggested that a virtual school could have large numbers of students. There are no physical restrictions such as the size and number of classrooms or the distance of a student's home from school to create limits to the number of students who can be part of a network that enables them to find the instruction they want. Nobody knows how many million people are linked today by Internet, a network of scholars and academics which is already being used for virtual classroom instruction. It links people in communities with mutual interests, lets them enter the catalogues of great libraries in many countries and write books together even though the authors are in different places. The people who use it, like the hypothetical student, are only aware of that part that they are involved with. Although they can explore its multitude of possibilities, its size is so great and it changes so much, so quickly, that no individual could know it as a whole in the way they could be aware of a conventional school. An advantage of an educational system as an international network is the variety of courses that could be accessed and the opportunities to link with like-minded learners around the world.

This is a vision of the kind of educational system that could become possible in an information society, a virtual network of learners, teachers, knowledge and examples of the problems the learners want to solve. The whole emphasis in instruction tilts towards the learner who is encouraged by the process to become a selective sophisticated lifelong customer for educational services that bring learning to the learner at the learner's convenience.

This vision is premised on the basis of the development of the information technologies that permit virtual reality. Writing of this technology Barry Sherman and Phil Judkins note:

"... at their outset, most technologies can be considered neutral. It is we, the people, who determine how, where and for what they are used. And as the world grows more sophisticated, and its parts increasingly interrelated, so these decisions get more difficult and more important. Virtual Reality is the most recent of links in this long chain, and like these other fundamental changes - radio and television included - it will offer us visions of hell as well as the more widely promised glimpses of heaven" (Sherman and Judkins 1992: 13-14).

In arguing the case for a new paradigm of instruction based on virtual learning environments, there is a tendency to focus on the positive possibilities. There is, however, another side to the vision. In our research the authors had to deal with problems caused by differences in time and culture which are inherent in interacting between countries. Some of the problems were predictable such as the way some teachers felt threatened by the technology and the fact that students wanted real social contact with each other. Other difficulties were less expected. There were intransigent problems in the technology itself and unexpected behaviour patterns such as the exaggerated communication on E-mail known as 'flaming'. These are some of the concerns in the telelearning pilot projects that are taking place around the world. What will be the social, economic, political and psychological consequences if the virtual class becomes the dominant mode of instruction?

With growing momentum, the copper cables of the telephone system are being replaced by cables of glass fibres. They are criss-crossing the oceans and going into place on the main trunk lines. Glass is beginning to replace copper on branch lines and inner city loops. Heavy users of information such as universities, hospitals, airports and large businesses are acquiring their own fibre optic networks. Some time in the next century fibre optics will reach out to individual homes. Major developments are taking place in satellite and cellular telecommunications. The infrastructure of the information society is going into place now. In Singapore and Japan intelligent cities are actually being constructed. As Bernard Woods points out 'the new systems will come about rapidly, driven by their potential profitability, by the new markets they create and by the new solutions they offer in the social sector' (Woods 1993: 133). Woods argues that we are living in a dual reality; what is possible now and what will be possible in the near future as information technology infrastructures being planned now come on line (Woods 1993: 133-134).

In civil engineering, planning horizons may be 20 years ahead as people think of the amount of water and waste disposal that will be needed to match birth rates, and the kinds of dams, roads, seaports and airports that will be needed to match economic plans and forecasts. A similar planning horizon is needed for education. It must go beyond trying to match schools and teachers to birth rates as if there were no other way. It must begin to look at how educational systems can be matched to the needs of the societies of the future and at the alternatives that the technologies that are transforming every other aspect of life could provide for learning It must go yet further and consider that to radically change the ways in which we learn is in its turn to radically change society. By thinking ahead in this way and describing future scenarios that are possible with new information technologies, it is possible to create a debate about foreseeable advantages and dangers and to influence the shape the future actually does take in education.

BALANCING CONVENTIONAL LEARNING AND TELELEARNING

Does telelearning mean the end of the classroom as we know it? The idea of people gathering together in some special site for learning goes back well before the industrial revolution and the classroom by itself has proved a remarkably resilient and durable place for learning. What we may see happen is the reversal of the trend toward big schools especially in the secondary and tertiary levels of education, and a return to something more like the village school and the small rural college, which catered to neighbourhood communities, where the catchment area meant it was possible to walk or bike to school rather than use motorised transport systems.

Children and adults need to learn socialising skills. Team sports, swimming, playing music, pottery, drama and singing are all reasons for people coming together for learning. Embedded in such activities are the interpersonal and group communication skills people need to live with each other. Where city schools drew large numbers of students it was possible to cater to a wide variety of educational needs . Small schools could not offer the same range of subjects. However, telelearning promises to make it possible to offer a variety of courses that no conventional school could match. In telelearning there are no physical limits to the number of courses that can be offered; it even opens up opportunities for the development of an international trade in teaching where an individual learner can access courses and teachers anywhere in the world in whatever subject they want to study, provided that someone, somewhere, wants to teach it.

Research suggests, however, that there was the need for a balance between computer interaction and human interaction. In the future we will need to strike a balance between telelearning and conventional classroom learning (Tiffin and Rajasingham 1995: 5).

WHY THE SEARCH?

Worldwide, societies are doing research to see how they can respond to the demand for education and training that will equip people to survive in the fast changing environment as a result of the developments in information technology.

Because education systems are designed to meet the needs of past environments, the gap between the needs of evolving information societies and the response of their education systems appears to be widening. Educational systems are preparing people for the past, for the ideas and attitudes and values of a way of life that is fading away and for work in areas of shrinking labour requirements. Schools seem unable to respond to the new needs of the societies which support them.

Public education systems prepare people for their place in society by emulating the factories and offices of an industrial society. Everyday, around the world, young people use bikes or buses or cars or trains to travel to school, just as later in life they will travel to work. They are expected to clock in at fixed times and they learn to work at desks in classrooms that are like the offices of industry and commerce. The way time is managed, subjects are segmented for study and schools are organised as bureaucracies are imitations of life after school. When the bell goes at the end of a school day, students stream out to commute home, just as factory and office workers do an hour or so later.

Like shopping, or business or work, education takes place at fixed times and fixed places on fixed days and depends upon a transport network of roads, railways and airways. However, it is becoming obvious that industrial societies which were served well by conventional education systems are undergoing a transformation. They are becoming information societies. This means that the majority of people are involved in information work and information work is becoming increasingly associated with the use of computers and telecommunications. These technologies are themselves evolving with digitisation and convergence of telecommunications, computers and broadcasting. We are getting smaller, faster and smarter information technology and soon we will be able to talk to our computers as information superhighways come into place making it possible to telephone people and objects as three-dimensional teleprescences.

We live in a period of transition between an industrial society and an information society. Schools as we know them, are designed to prepare people for life in an industrial society. What kind of system is needed to prepare people for life in an information society?

THE NEED

Societies worldwide share the need for effective, cost-efficient instruction that can match the needs for skills related to technological change, delivered interactively, at the convenience of the learner. The learner, no matter where their physical location, should be able to interact with the teacher, with the content and with one another in synchronous and/or asynchronous mode.

This is telelearning. As telecommunications and computers merge, new ways of learning and teaching will challenge the traditional classroom, not to replace it but to provide alternative and complementary ways to extend educational and training opportunities for more people than is possible with conventional classrooms. These new technologies create a communications environment where the functions of a classroom can take place at different locations. This is the virtual class where teachers, learners and curricula interact in telepresence.

In 1884 Samuel Morse sent a message from Washington to Baltimore asking "What hath God wrought?" This question remains unanswered more than a century on as we grapple with the wonders of the superhighways of information. Marshal McLuhan, best known for his apothegm "the medium is the massage" also coined the term "the global village" and talked about the way societies drive into the future while looking into the rear view mirror. Education is preoccupied with the problems of the past. However, as our environments become global and commercial, our education systems are caught in a timewarp, unable to adapt to the needs of the information society.

Does the problem lie in the way education is administered, the methods of instruction and the content of curricula? These are the issues that advanced industrial societies focus on as they attempt to find a solution. In our book, our concern is with the extent to which the problem lies with the classroom as a communication system for learning. Our argument is that the classroom is a technology that emulates the way people live and work in an industrial society. It does not relate to the way people will live and work in an information society.

EDUCATION IS COMMUNICATION

> "What is demanded is a change in our imaginative picture of the world" (Bertrand Russell 1925 *ABC of Relativity* p.1).

Shannon and Weaver in their seminal book **The Mathematical Theory of Communication** said:

> "...it is clear that communication either affects conduct or is without any discernible and probable effect at all" (Shannon and Weaver 1949:5).

Education is the practice of a kind of communication. What are the fundamental communication functions that allow education to take place? How does the classroom facilitate such communication functions? How can the use of information technology such as virtual reality and multimedia improve the classroom?

It would be true to say that all of us, at some time, need some assistance to acquire complex sets of skills that are external to us. The term education is used to include training, life and citizenship skills; and learning without direct supervision, through mediated instruction as in the case of distance education or self teaching materials. However, the primary locus of education is seen to be the classroom. In seeking to improve the classroom by using technology it is necessary to establish a relationship between the ideas of information technology, communication and education. As industrial societies become information societies, conventional communication systems are becoming information systems. Where, for example, communication was based on paper transactions and face to face meetings in rooms there is now increasing use of information technology. From depending on transport systems to get people and paper to the place where business is done, society is beginning to use telecommunications to similarly move information to where it is needed.

If communication is the process of moving information from one source to another, the process of education can be described in terms of moving information from a source that has the information (for example, a teacher) to someone who is yet to learn how to use the information (the learner). Of course, both a person's genetic endowment and their environment contribute to the way they develop. However, is a violent, unsociable, unemployable person the consequence of a genetic predisposition, or a lack of parental guidance, or what they see on television, or a failure of classroom teachers? Whatever the prime factor, a positive way that we have to prepare people for their part in society is by creating an effective educational communication system for those that need it.

One advocate of the environmentalist approach in education whose work has provoked interest in recent years is Lev Vygotsky, and his concept of a Zone of Proximal Development (ZPD) provides a basis for looking at education as communication.

Simply stated, according to Vygotsky, the ZPD is the difference between what a person can do by themselves and what they could do with help from people more experienced than themselves (Vygotsky 1978). The ZPD implies that any educational system involves people who have roles as teachers and as learners and a communication process between them that allows the teachers to help the learners to solve problems that they would not be able to solve by themselves. In addition, 'problem solving under guidance ... or in collaboration with' means practice and feedback, and a two-way interactive communication process between teachers and learners that is dynamic. What Vygotsky did not have in mind in the pre-computer era he lived in, is the possibility that the helping hand for the learner need not be human. Nor could he have realised that developments in telecommunications as well as computers would mean that the teacher, human or otherwise, could be anywhere and only present with the learner in a virtual sense.

THE FOUR CRITICAL FACTORS OF EDUCATION

In his ZPD, Vytgotsky specifies three factors in the educational process:

* someone in the role of the learner;
* someone in the role of the teacher; and
* something that constitutes a problem which the learner is trying to solve with the help of the teacher.

By implication there is a fourth factor: the knowledge needed to solve the problem (Tiffin and Rajasingham 1995).

It is the interaction of these four factors: learner, teacher, knowledge and problem in a particular context that constitutes the fundamental communication process that is education (Tiffin and Rajasingham 1995).

How can the new information technologies intermesh the four critical factors of education? Can they create an effective, complementary and or alternative to the classroom?

THE CLASSROOM AS A COMMUNICATION SYSTEM FOR EDUCATION

Unlike the home or the workplace, the classroom is dedicated to teaching/learning. Most people in an industrial society will associate it with schools which are normally clusters of classrooms with an associated infrastructure for administration, management and support. However, classrooms can also exist in the buildings of large companies and in churches. Any large military establishment will have its classrooms. For the Romans it was a room in a wealthy house or at the side of a street. The classroom at Mari was an integral part of the city itself. In Ethiopia, priests use parts of the church to teach. In India, students have gathered under trees for learning for thousands of years. Then there are science laboratories, gymnasia and classroom workshops for teaching metalwork, woodwork and domestic science. The places dedicated to instruction take many forms, but for most people in most countries a classroom is a rectangular room with rectangular desks and a rectangular blackboard. This formula for facilitating learning has spread around the world. This is what we mean when we talk of the conventional classroom. It is a remarkably successful and resilient communication system for instruction. If we are to improve on it we need to understand how it has survived and multiplied.

THE PURPOSE OF CLASSROOMS

Classrooms emulate the places where people live and work, especially the work world of offices. They are designed to teach people how to deal with problems as they are represented in abstract by language and mathematics. Classrooms developed in early civilisations to teach reading, writing and arithmetic. The growth of cities depended on systems for recording and storing information in language and numbers and a cadre of clerks was needed. However, as the ancient Greeks realised, the ability to abstract reality in language and number also made it possible to manipulate and control the world, create scenarios of what could be and search for explanations of why things were. The tools of the mind in the form of written language and mathematics have in urban civilisations been the real source of power and control rather than the tools that are used to deal directly with the world. The classroom is first a learning system for acquiring the basic skills of literacy and numeracy, but it then has the potential to give access to the storehouses of written knowledge which are the sources of power. It is hardly surprising that classroom learning should be associated with the ruling elites of pre-industrial civilisations or that in the development of democracy in industrial societies there should be a demand for classroom education as a right for all citizens that is as basic as universal suffrage.

The coming of an information society is seen as depending upon a workforce educated in the skills and literacies of information technology. It is hardly surprising that the information industries are supporting reform in education. There is a growing argument for a better educated population as a solution to unemployment as industrial societies restructure to become information societies. There is also a growing tension between those who see education as a preparation for work and those who see education as development of the whole person.

HOW DOES THE CLASSROOM FUNCTION AS A COMMUNICATION SYSTEM?

Like the home and work educational situations, the classroom permits broadband, fully meshed, fully interactive communication that can be multimedia and address all the sensory channels. Classroom education does not, however, normally involve people in tasting or smelling or even touching in the way that family or work education can. It is essentially concerned with sight and sound. The walls keep external sounds out and internal sounds in. Ideally, windows allow in light that does not carry distracting information and is sufficiently diffuse to make reading easy.

Why then search for a complementary or alternative loci for learning? Our research indicates that if education is to respond to the fast growing demands of societies for education and training needs then it seems that a solution may lie with the development of its communication system. The classroom by itself, as it is, is an inadequate communication system for all an information society's education needs. But it would be a mistake to totally replace what happens in it with a virtual class. The purpose and function of the conventional classroom needs to change and much of what is now done in the conventional classroom could be better done in a virtual class. The classroom, although it may change will be around for a long time to come and needs to co-exist in parallel and harmony with the virtual class.

THE CRISIS IN EDUCATION

Just as the railways brought the industrial society and education systems were devised to serve the needs of the industrial society, so the Internet, which is this decade's metaphor for the information superhighway, will herald the information society. Philip Coombs first talked about the crisis in education in 1968. He revisited education in 1985 where in his book The World Crisis in Education: a View from the Eighties, Coombs and other researchers noted that the crisis in education was deepening and was becoming worldwide (Coombs 1985; Altbach 1985).

What is the crisis? It appears that we are yet to address the implications of the changing technological environment for education and indeed society. Universities are more traditional and conservative than any other sector, and are at risk from the oncoming technological revolution in education. As university students gain access to the Internet and the World Wide

Web they will have a growing choice of courses that they can take via the Internet. They will no longer necessarily be constrained by the courses offered in the national universities. Consortia of universities catering to the global market for professional skills will provide smorgasbords of courses that are up to date and related to the new developments and new subjects. Not only will students have choice of subjects, they will also have choice in when they study, how they study, where they want to access study from and with which experts. Their needs will be catered to.

Robert Reich (1991) notes that as politics, economics and infrastructures become internationalised, there will no longer be national economies in the traditional sense of the concept. "All that will remain rooted within national borders are the people who comprise a nation. Each nation's primary assets will be its citizen's skills and insights. Each nation's primary political task will be to cope with the centrifugal forces of the global economy which tear at the ties binding citizens together-bestowing ever greater wealth on the most skilled and insightful, while consigning the less skills to a declining standard of living." Global solutions need internationalised knowledge. Just as national economies are jacked in to global, so national education systems and classrooms are facing major challenges.

Options and costs

While information technology offers choice of mode, time and place for learners, what about the costs? Research (Rajasingham 1988; Renwick 1984, cited in Bigum and Green 1992: 213; Marginson, 1993) shows that the costs of studying in a conventional classroom will go up while the costs of telelearning using information technology is falling. Brick and mortar and transport costs are rising because these are energy dependent on fast depleting extractive fuels. Every extra 20 or 30 students in a conventional education system means another classroom has to be built and another teacher trained. By contrast, the more people enrolled for a course in a virtual university, the less it costs per capita. There are no buildings to put up, no maintenance to provide, no car parks or road access to find, no cafeteria or rest rooms needed. As education and training become lifelong activities (Holmberg; Moore; Rajasingham) education could become the growth industry of the next century. Technologists and entrepreneurs like Bill Gates and Rupert Murdoch are gearing up for the coming trade in teaching. Consortia of universities being formed in Australia, Canada, Latin America, the United States and Europe are intent on finding their niche in the market.

Are telecommunications costs really becoming less than those of transport? Today telecommunications costs tend to be artificially high and transport costs artificially low. Governments subsidise transport systems and perpetuate an industrial society while telecommunications companies who often have a monopoly make handsome profits as the user pays. Moreover, telecommunications costs are distorted. Long distance calls cost considerably more than local calls. To a transport-based mindset this makes sense . The greater the distance the more we expect to pay for using telecommunications. However, this may not reflect the cost to the telephone company. The satellite link on an international call that spans the world is a tiny fraction of the actual cost of an international call and if a satellite is used it does not matter whether the transmitting and receiving dishes are 10 metres or 10,000 kilometres apart. It is the ground system at the local level that is expensive. Many countries enhance the distortion by subsidising free local calls from long distance charges. If there were to be a genuine level playing field for transport to compete with telecommunications then it would be relatively expensive to use telecommunications over short distances, but relatively inexpensive over long distances. The greater the distance, the greater the economy of using telecommunications.

In the long term, fibre optics will reach most of the homes in an information society and accessing satellite communications could continue to become increasingly simple and inexpensive. The difference between local and international calls is diminishing as competition grows and as satellite technology presents an alternative to terrestrial systems where distance does not matter. As this happens it becomes of little concern where a person is when they are using telecommunications. This makes possible what could well be the biggest difference between the conventional classroom and the virtual class. Transport systems such as roads, railways, shipping and airways respect national boundaries. Immigration and customs barriers can be erected across roads and railways and at airports and wharf sides. Information does not need customs or passport formalities to cross borders. Transport-based conventional classes are organised nationally. The virtual class, because it uses telecommunications, can be global. Furthermore, as more people begin to access the Internet, telecommunications costs become negligible compared to the costs of transport.

The global educational utility

Denis Gooler described the National Utilities Corporation's concept of an educational utility thus 'The education utility consists of a massive and dynamic reservoir of information and educational programming, from which individual teachers and learners can select the information and education resources they wish to work with, and when. The appropriate information can be transmitted via a state network in an economical manner to the school or site requesting the information' (Gooler 1986: 18). He looked at the idea that providing information is the answer and that such network technologies are levers to get schools back on their feet. However, Gooler looks beyond schools to the way such a network can provide knowledge in homes and become international. What is interesting is the way he uses a water utility as a metaphor for an educational utility with the idea of some reservoir from which knowledge flows that can be turned on like a tap as a basic part of civilised life.

We prefer the metaphor of the electrical utility. This was first developed to bring electric lighting. Then it became a universal source of power for such things as heaters, fridges, stoves and radios. It became a norm to put plugs in homes so that people could plug in any device that worked with electricity. Because of this, more and more devices were powered by electricity. Part of the basic infrastructure of an industrial society is its power grid. Progress, as a civilised society, is having electricity available anywhere, anytime and at reasonable cost for all citizens.

Telecommunications were first set up to provide telephone and telegraph services, but they have now begun to serve other information needs. It is becoming standard to put jackpoints in rooms so that people can jack-in information devices such as computer modems, fax machines and security systems as well as telephones. In the future, in an information society, information will be available anywhere, anytime, like electricity. It will be possible to telephone microwave units to have a meal ready by a certain time. Fridges will be able to telephone a store when they are short of butter or bacon. A crib will get in touch with a parent to say the baby is awake or not well. The plain old telephone system is becoming an information utility. But there is something further. It is possible for a third party to use a telecommunications system to provide some special service that adds to the value of the basic telecommunications service. Examples of these are E-mail services and telebanking. They are called value added network services (VANS). Education could be a VANS.

VANS can operate at international levels when they are called an international value added network service (IVANS). If a point is reached where there is little difference between international and national telecommunications costs then the way is open for global competition between providers of network services. The issue of free trade in information services is of growing concern in discussions on General Agreements in Trade and Tariffs (GATT) and in the newly formed World Trade Organisation (WTO). The superhighway telecommunications systems of the future could allow free international trade in telebanking, telemedicine or teletranslation services. It could also mean free trade in telelearning as an IVANS.

But roads will not disappear; classrooms will not disappear. However, there will be an alternative, a complementary loci of learning: a virtual class.

THE VIRTUAL CLASS

'Virtual' means in effect but not in fact and 'tele' means at a distance. For example, the telephone gives the effect of a presence and since the effect is achieved with people who are at a distance from each other, it is a virtual telepresence, but only in terms of their voices. The new breed of telecommunications brings not just sound, but also images. Video phones are available and videoconferencing in the business world is becoming standard for meetings. These techniques are already being used experimentally for education, making it possible for teachers and students to meet, as telepresences in televirtuality. Already we begin to talk of teleschools and virtual classes as an extension of, or alternative to conventional schools and classrooms.

Virtual reality

The virtual class is made possible by virtual reality technology. Virtual in this context means reality in effect, not in fact. Already we are aware of virtual universities, virtual schools (Rossman 1992) and virtual classes on the global communications network, the Internet. This network allows people separated by distance to meet by writing to each other. Today, the technology for basic virtual classes exists. Technologies such as videoconferencing and multimedia allow a virtual class where we can see and hear each other. However, research shows that we are slowly able to move our whole bodies into a virtual class. For example, it is possible to attend a virtual class by putting on a helmet; by putting on data gloves our hands in a virtual class can write on a virtual whiteboard. Research currently being done in Japan, Europe and the US suggests that one day we will be able to step inside a virtual learning environment as full bodied telepresences that can hear, see, talk with and even touch and smell other telepresences in classrooms and communities that are virtual simulacra of the subject being studied. We could study the human heart inside a heart; study Hamlet inside Elsinore Castle; the history of India during Shah Jehan's time inside the Taj Mahal, and so on. In such a virtual seminar students in New Zealand could meet with students in the USA, Europe and Japan as telepresences where they can see each other in three dimensions, talk to each other and even touch each other and the virtual objects that they share. Such a facility is scheduled to be commercially developed by the year 2000.

These new technologies that make us independent of transport systems will mean a growth in teleworking, teleshopping, telebanking, and telemedicine and, to prepare people for life in such a society, telelearning. The place where telelearning takes place is a virtual class in a virtual school, college or university. The main idea of a virtual class is that students and teachers meet by using telecommunications instead of transport. Today this means audio or videoconferencing, but in the future it will be possible to teleconference in three-dimensional virtual reality. Furthermore, in future, using hyperreality, people and objects in the real world will be able to interact together with computer-generated fully integrated images of people and objects in remote locations using spoken word, texts and pictures. Nobuyoshi Terashima, President of the Advanced Telelcommunications Research Laboratories describes HyperReality as the technology that allows "real and unreal objects to be able to co-act in a single space to create an extremely realistic environment ...connected by communication lines"(Terashima 1995). We are currently researching this area.

Today virtual educational institutions such as the global electronic university are springing up on the Internet. And like the Internet, they are global in nature. Educationists and policy makers in all societies are engaged in discussions as to how to put in place these technological changes. There is widespread agreement from Sweden to Singapore, from Australia to Latin America, from the US to Japan that students at all levels of education will, in the very near future be using computer technology to access telecommunications networks and that these technologies will become more powerful, have global reach, offer more comprehensive services and be much easier to use than they are today.

What happens when students have the technology and are all on the Internet? What happens to national education systems? In particular, what will happen to universities as we know them?

ANTECEDENTS OF THE VIRTUAL CLASS

Figure 1 shows the salient characteristics of education in the pre-industrial, industrial and information societies.

	PRE-INDUSTRIAL SOCIETY	INDUSTRIAL SOCIETY	INFORMATION SOCIETY
LANGUAGE OF INSTRUCTION	Latin and Greek	National Languages	English
LEARNERS	The Young of the Elite	The Young People of a Nation	Everyone
AGE OF LEARNERS	6 to 20 Years	6 to 16 Years	Any Age
PAYMENT	Parents	Through Taxes	User Pays
PROVIDERS	Church	State	Corporations
WHERE AVAILABLE	Sites of Knowledge	Towns and Cities	Anywhere
WHEN AVAILABLE	Arranged Times	Set Times	Anytime
ECONOMIC TRADITION	Traditionalism	Taylorism	Neo Liberalism
SOURCE OF CURRICULUM	Teacher	State	Learner Needs

Fig. 1 Salient characteristics of education in pre-industrial, industrial and information societies.

The conventional classroom

The conventional classroom as the locus of learning has been around for many hundreds of years. It has been most successful in meeting the needs of the societies they served and provided an effective, multimedia and interactive environment for education processes. However, as economies become information based and global, new kinds of education and training systems become necessary to produce people with internationally competitive skills.

To survive, the classroom depends on rapidly depleting, finite extractive fuels used for buildings and travel. Also the bureaucratic structure of traditional educational systems which are usually bastions of conservatism makes it difficult for them to incorporate changes in curricula rapidly.

Two by four by six education, where learning is contained within the two covers of a book, the four walls of a classroom, for six hours a day may be in trouble but it has proved to be remarkably successful. The classroom's primary strength is that it provides an efficient multimedia communication environment. The students can have synchronous interaction with the teacher and with the content using the blackboard/whiteboard as well as asynchronous interaction as they are guided through their assignments and so on. The communication process in a conventional classroom uses the five senses of sight, sound, taste, smell and touch. Communication takes place through the spoken word, written word and image, both still and moving. Attempts have been made since the beginnings of distance education to replicate the learning environment of the classroom so that, in Borje Holmberg's words, the "didactic conversation" can take place effectively even if teacher and learner are separated in space and time. This is distance education.

Distance education: traditional

Since very early times, there were people who could not attend schools because they lived in remote areas, could not afford the travel, had a disability, or would not do so by choice. For these people distance education was the only access to learning.

Distance from educational opportunities can be measured not only in kilometres but also in terms of social or economic inequalities. It may be just as difficult for someone living in an urban area to attend classes on a campus as it is for someone living in a remote rural location. Distance education relies on communication technology to bridge the gap between teacher and learner, and historically this was correspondence and postal based. It has a long history and most countries have had successful distance education programmes since the 19th century.

There have been many attempts to solve the problems of education with communications technologies. One of the first was to use postal services. The forties and fifties saw the introduction of film and radio and the sixties and seventies saw the rise and fall and rise again of educational television. The eighties were the decade of personal computers in schools. The nineties look set to be a time for experimenting with telecommunications in education. So far, however, none of these technological initiatives has posed a serious threat to the dominant technology of education, the classroom. We need to know why.

In retrospect, the idea that television, correspondence or computers could, by themselves, provide grand solutions was naive. As we have seen, the conventional classroom is a sophisticated, fully integrated, broadband, multimedia environment which is capable of most of the communication processes involved in instruction. The mono technological approaches did not have the same technological capability. Print, radio, television, telephones and computers have been used in distance education around the world since the late 18th century. However, their success was limited because they allowed limited synchronous interaction between teachers and learners which is critical in the learning process.

However, these first attempts are widely documented in their day as panaceas for educational problems. They had their converts and believers and their successes, but they also had their failures and they have never looked like superseding the classroom.

In this decade, the process of digitisation is facilitating the convergence of computers, telecommunications and video allowing us to communicate using sound, text and pictures in sophisticated combinations that replicate multimedia environments of traditional face to face communication in a classroom.

New distance education: Telelearning

A UNESCO Report published in 1993 identified distance education as the fastest growing sector in the knowledge-based world economy. As communications technologies move towards digitisation and convergence a new kind of distance education called telelearning is becoming available. Today this includes teleconferencing, audiographic and videoconferencing, based on the telephone. These interactive technologies can be used successfully in teaching, creating, interpreting and integrating knowledge for problem solving.

The application of new developments in telecommunications to instruction is called telelearning. There are two basic modes, synchronous and asynchronous.

Synchronous communications are when the transmitter and receiver operate in the same timeframe, as for example, in educational television. Asynchronous communication is when the transmitter and receiver of a message are not acting in the same timeframe, as for example, in correspondence courses. Communication in a conventional classroom switches easily between synchronous and asynchronous modes as teacher and learners move from discussion of a topic (synchronous) to an exercise that the teacher writes on the whiteboard as an assignment to do at home. Telecommunications can also switch between the two modes but it is not yet a smooth transition because it means using different technologies. Fax, E-mail, bulletin boards and computer conferencing are asynchronous technologies for telelearning. Teleconferencing is the synchronous transmission system that brings teachers and learners together in realtime as electronic telepresences. It is this which makes possible the idea of a virtual class.

SYNCHRONOUS TELECONFERENCING

Synchronous teleconferencing today takes three forms: audioconferencing, audiographic conferencing and videoconferencing. In the second half of the nineties distributed multimedia conferencing systems will develop. In the scenario earlier, for Learner 2000, in future, it will be possible to teleconference using computer generated virtual reality and this is the direction in which teleconferencing will move and it is at this level that it will profoundly change education.

Each form of teleconferencing is an attempt to use telecommunications to reproduce the kinds of synchronous communication that take place in classrooms. Ideally, therefore, although the people in a teleconference are in different places, the following communications should be possible:

- Everybody should be able to hear each other and talk to each other.
- Everybody should be able to see the person who is talking.
- Everybody should be able to see what is on a whiteboard and be able to draw and write on it so that everyone else can see.
- Everybody should be able to see any audiovisual materials used such as video or slides or multimedia presentations.
- Everybody should be able to handle and interact with any object, machine or equipment that relates to the class.
- Everybody should be able to take away a copy or record of what was studied in the class.

All these functions are possible in a conventional classroom at the cost of travelling to the classroom at fixed times. Note, however, that there are some significant restrictions such as the number of people that can be in a particular classroom, and the objects that can be introduced. Students can study twigs in classrooms but not trees. Although audiocassette recording and laptop computers are now appearing in lecture theatres, records of what transpires in class are seldom more than paper-based notes and handouts. These kinds of restrictions suggest ways in which teleconferencing could actually improve on the classroom. However, although today's teleconferencing technology solves the transport problem it cannot provide all the communications facilities of a classroom. Moreover there is added cost for each additional facility it does provide.

ASYNCHRONOUS TELESERVICES FOR TELELEARNING

Facsimile is an adjunct of telelearning systems, not only for instruction but also for administration. It is a convenient way of sending pages of text and distributing timetables, brochures, lecture notes and assignments and last minute materials. However, fax is not yet an easy way to transmit large amounts of text and where long distance calls are required, it is costly. Postal or courier services are better until the next generation of fax machines can deliver large quantities of text rapidly and inexpensively. It is, however, electronic mail (E-mail) and other network services that are proving the most powerful force in telelearning in the mid-nineties.

To access network services that offer E-mail, a user needs a computer with a modem. This is a piece of equipment which links a PC to the telephone system. Like a telephone enables a human to use the telephone system by translating sound waves into electronic signals, a modem translates the electronic signals from a computer into electronic signals that can carry over telephone lines. In this way, computers can 'talk' to each other by telephone. The user will also need a password and some software. With this they can log--on and use the system. If they use

E-mail they can send mail or read mail that has been sent to them, print or file mail, reply to mail or forward it to someone else. If everybody in a telelearning system has a PC and access to an E-mail system, it can be used to distribute information to a class as a whole, to individuals or to groups, for tests and examinations and for readings and assignments . Students can do work on a wordprocessor then send it as a file to the teacher who can correct it and return it.

Bulletin boards systems (BBS) can be set up where messages can be posted for periods of time so that they can be read by anyone who is interested and it is possible for readers to add their own messages. BBSs usually have some special theme and are a focus of debate. Computer conferencing is a form of BBS which restricts interaction to people in a special interest group (SIG). In this way it can provide a means for a class to interact on a subject asynchronously. We have found that with computer conferencing linking people from many parts of the world, the whole class would contribute to and develop the content of an assignment in a manner that would have been beyond any of them individually.

Another important area for education is online database services. These are collections of information stored in computers which can be accessed via a network. The information can be on current events, the stock market, agricultural prices, courses offered at colleges etc. What especially interests telelearning is access to libraries. At the moment the catalogues of many libraries can be accessed, but it is not normally possible to download the text of books once they are located. When this does becomes possible, the virtual class will have its virtual library.

As noted, it is the linking of learners, teachers and content in telepresence that make possible the virtual class. What are the technologies and modes that allow us to create the communication functions of the conventional classroom at remote sites?

Audioconferencing

The most basic way of using telecommunications to provide a virtual class is audioconferencing. The intention is that teachers and learners in two or more sites can all talk to and hear each other. This is not a computer mediated form of communication. It uses existing analog telephone technology.

The telephone system was designed to link two telephones for two people to talk. To link more than two sites requires a 'bridge'. Conference calls, which bridge several telephones are standard telecommunications services and inexpensive bridges can be installed at teleconferencing sites that link five or six telephones. Such bridges can be linked to each other to provide a mosaic of connections that is user controlled and theoretically unlimited. Bridges that link large numbers of telephones together from a central hub are expensive and because all calls radiate from the centre where the bridge is, transmission costs can be high, especially if the other nodes are widely distributed and involve trunk calls.

Teleconferencing can link individuals or groups. With small groups a telephone with a speaker is adequate. With large groups linked push-to-talk microphones or voicepoints are used.

In his research in educational television, Tiffin (1976) concluded that the real instructional message in educational television was in the sound and not in the pictures. The problem in audioconferencing, however, is in the sound. Telephone systems were not designed for more than two links. Echo formation and acoustic coupling in analog telephone systems increases with the number of lines involved in an audioconferencing network. The trouble involves many variables some of which may act in opposition to each other. For example, reducing ambient noise means closing windows, shutting off air conditioning and creating an electronic sauna. Seeing someone talk, as in a classroom, helps to decipher what they are saying. There are no visual cues in audioconferencing and the telephone system distorts the voice. Audioconferencing technology is improving. There are dedicated audioconferencing systems and techniques for coping with the limitations which, after years of tinkering, function well. A critical component of audioconferencing is some kind of 'cannot hear' button. When people participate in audioconferencing they learn how to talk into microphones and new protocols of speaking.

There are dangers in this situation. Learners can easily become frustrated. In audioconferencing if the sound does not work there is little to fall back on. Audiocassette recordings that can be copied and sent to any centre that has poor sound reception are a limited solution.

Mutual intelligibility between all participants in an audioconference is only a first level requirement. Students who use teleconferencing extensively want more than this. Since they cannot see the speaker they want, as one telestudent put it, to 'hear the body language in a voice'. They want the subtleties of tone and inflection which provide the underlying affective message in verbal communication. Our telestudents said that it makes a difference when they have met with other students and teachers because they can imagine what they are looking like as they are talking. It helps in audioconferencing to have photographs of the people at different sites where they can be seen on some noticeboard at each conference centre and students at different centres sometimes make videos to introduce themselves and show what their centre and its environment look like.

Audioconferencing systems that are well established and have worked through their sound problems seem to function well. There is an imposed parsimony in the medium that may diminish the affective but augment the cognitive in learning. Audioconferencing systems mail materials out to centres for use as graphics during an audioconference. In this way slides or OHPs can be shown on cue when someone is talking or people can look at handouts. Mailed materials can also include take-home work and exercises. Audioconferencing systems are sometimes linked with correspondence systems, a logical matching of synchronous and asynchronous instructional systems. Another integrating development has been the juxtaposition of audioconferencing with instructional television. Narrowcast transmission by satellite of an educational television programme is followed by an audioconference. This has become popular in business training in the USA where it is sometimes called Business TV.

This is a virtual class where the telepresences have their eyes closed. Although such systems once established work well and are economical, the students seek to see.

Videoconferencing

As the name implies, this kind of conferencing uses video cameras and monitors at each centre so that participants can see as well as hear each other. It is also possible to show pictures of whatever is being discussed. The trouble is that video images need a lot of bandwidth and the superhighways are not yet completed. Videoconferencing has been expensive. This is changing with the application of compression techniques so that less bandwidth is needed. The amount of information in each frame of video and the number of frames per second can both be reduced though the results are low picture definition and motion that appears jerky. In this way it becomes possible to videoconference using the public telephone system. The cost of cheap, easily available videoconferencing is, therefore, low quality pictures. This takes us back to the question addressed in the discussion on educational television. Why do we want the pictures?

Videoconferencing is mainly used to show people talking to each other. When it is used for instruction the tendency is to show pictures of students and teachers rather than explicit images of the subject that is being studied. Since images are low quality, they need verbal explanation. In the interactive debating mode of teleconferencing the interest is in the affective aspect of seeing who you are talking to and how they are reacting to what is being said. We have argued the case for parsimony in presentation and that the simultaneous use of audio and video modes unless they complement can overload our capability to critically interpret information. The affective message contained in the visual image of the person talking can distract from the basic cognitive content in the audio channel. Yet, the assumption continues to be held, as it was with educational television, that education with moving pictures, no matter what the quality, is better than education without.

Videoconferencing is primarily used to look at the people who are talking, but the more people who appear in a picture, the less clear is their image. The system is at its best when it uses the full screen to show the person who is talking in close up. In other words when it acts like a video phone. Voice activated cameras are used that automatically get a shot of the person talking. Some systems use preset camera positions that make it possible for a conference convenor to select a shot of the person talking.

Videoconferencing has its own variety of problems. Cameras need light, but projected images need darkened rooms. Videoconference participants are not television talent. They look at the image of the person they are talking to on a monitor, not at the camera. The result is they appear to be looking off camera and they do not have the eye contact which gives conviction to what they are saying. Although most videoconferencing systems have a camera for showing objects or graphics it is most likely to be used for showing text. Seldom are videoconferencing systems used to show visual phenomena with motion as the subject of instruction. When they do, someone with camera skills is needed. Videoconferencing centres do not normally employ people with artistic video production skills. Videoconferencing is where television was 50 years ago. This is a virtual class where the telepresences have their eyes open, but are myopic.

The answer to some of the problems of videoconferencing may lie in the advent of desktop video. By this is meant incorporating videoconferencing capability into a desktop computer. This represents the point in the mid-nineties when the development of the computer as a multimedia device converges with the development of telecommunications as a multimedia transmission system in a way that makes the technology easily accessible to many people. An individual can join a videoconference from a desk in their office or home and can see, hear and write to the other people in the conference. They can also send or present files of multimedia materials they have previously prepared. The synchronous and asynchronous modes mesh almost as easily as they do in a classroom. Slipping into this kind of telepresence could become as casual as telephoning. It brings the virtual class closer because it allows access by small groups and individuals to meet as telepresences.

Audiographic conferencing

An audiographic conferencing centre uses two telephone lines, one for sound and one for graphics, or, rather, for transmitting data between computers. The data appears on the computer screen as text or graphics. In other words, audiographic conferencing is audioconferencing with the addition of a computer link that provides a virtual whiteboard. Audiographic conferencing uses data bridges in parallel with audiobridges and the bridging possibilities are the same as for audioconferencing except that the line costs are double.

Every audiographic centre not only provides the means to talk to and listen to every other centre, but it also has a video display unit linked to a personal computer. This acts as the common whiteboard in the sense that every centre can add to it and every centre sees the same thing. It is possible to key in written messages with a graphics package and to draw pictures and diagrams. An electronic pen can make it possible to write directly on to the VDU screen. With an optical scanner it is possible to create files from existing documents. It is also possible to use a video camera to capture single frames that can be shown as still images. Because of the bandwidth limitations of the conventional telephone line, a single frame of video could take several minutes to transmit. However, text, diagrams and video frames can be prepared as files and downloaded to the different centres before an audiographic conference begins. During a conference, files previously downloaded can be called up. The graphic itself does not have to be transmitted at that point because it is already stored in the memories of the different computers. This also means that any device linked to the computers at the different centres can also be activated. For example, if all the audiographic centres had a videodisk or a videocassette player and the appropriate software, video sequences could be triggered. In this way all the centres could watch the same video sequence at the same time. The same could be

done for a CD player so that fixed pieces of music could be played at the same time. Inclusion of a CD-ROM player at each centre could mean that an encyclopaedic amount of information could be accessed in a conference.
In audiographic centres where there are 10 or more people, large video display units are necessary and with 20 or more people, electronic whiteboards are used. A VDU image is projected onto the electronic whiteboard and pressure on the electronic whiteboard simulates the effect of an electronic pen on a VDU screen. Although such systems are 'lash-ups' of bits and pieces of equipment, they are surprisingly effective and are leading to new modes of presentation.

Unlike videoconferencing where the different sites see reciprocal images because the purpose is to simulate a conference where everybody is looking at each other, in audiographic everybody is looking at the same picture. Although still images of the person speaking are sometimes shown, the pictures in audiographic conferencing tend to be more concerned with the subject that is being taught. Where videoconferencing appeals to the affective aspects of telelearning, audiographic conferencing focuses on the cognitive domain. It provides a virtual class where everyone can hear and speak to each other and can see and use the whiteboard. However, the telepresences cannot see each other. Students seek to *be* with each other.

TECHNOLOGY CONVERGENCE AND THE EMERGING VIRTUAL CLASS

The three forms of teleconferencing are linked and converging. Any synchronous electronic meeting is an audioconference. Any teleconference in the future will have to include the computer-mediated communications which is what is distinctive about audiographic teleconferencing and computers will subsume video. Video images are appearing in windows in audiographic conferencing systems, blurring the distinction with videoconferencing.

Each of the different modes of teleconferencing has links with the earlier steps in using communications technology to seek an alternative to the classroom. Audioconferencing has developed links with correspondence education, videoconferencing links to educational television and audiographic conferencing to computers in education. As the three modes of teleconferencing draw together they also integrate much of what was learned previously about applying technologies to education. To add to all of this, audioconferencing and videoconferencing are also linked to developments of multimedia in computers.

The term multimedia was originally used to describe media combinations such as sound/slide programmes, multi-image presentations and computer interactive video. It involved 'integrating each medium and medium format into a structured systematic presentation' (Heinich, Molenda, Russell 1985: 172). The term has now been adopted to describe the computer-mediated integration of different media. What this means is that the various sound and image recording media can be digitised for use with a computer.

Audiographic conferencing is an example of multimedia in the original sense because it combines two media - the telephone and computer graphics. It is also multimedia in the new sense because the computer graphics can be derived from a videocamera, an optical scanner or the computer itself. It is the way the computer screen has become a presentation system for sound and moving images as well as for text and graphics that is at the heart of the new multimedia movement. The computer has become a subsuming medium like television. Video shown via a computer is no more video than a film shown by television is a film. The video shown on a computer screen is digitised and this means it can be changed and adjusted by the user. It can be windowed and the size, shape and position of the window can be changed and the whole gambit of capabilities in whatever application package is being used can be applied to the subsumed media.

Computer based multimedia systems that include video require a large amount of storage space. The development of compact disks using laser optic technology has provided this. CD-Rom is a multimedia technology with the kind of storage capacity we associate with sets of encyclopedias. It stores sound image and text in digital form and allows the user to access an individual item of information in seconds.

Television, like a book, presents information in a linear sequence. This is decided on by the producers of programmes. Computer-based multimedia systems are designed so that information can be accessed by the user in the sequence that the user wants. In education terms, where ETV was teacher driven, multimedia is learner driven. What allows the user to navigate their way through all the information at their disposal in a multimedia system is a way of mapping information that was originally called hypertext. It is now called hypermedia in recognition of the fact that information could be in a whole variety of formats.

Multimedia systems can be networked. The World Wide Web (WWW) is a large scale hypermedia network for textual information that has embedded pictures, moving images and audioclips. There are problems, however, in navigating large data sets in distributed hypermedia. Users become lost in hyperspace. A distributed hypermedia system called Hyper-G is being developed at Graz University of Technology Austria to remedy this. It provides a variety of devices to help the user retain a sense of where they are in an information jungle. One is a 'local map' that shows the vicinity of a piece of information. Another is an 'information landscape' that the users can 'fly' over looking for salient information features (Maurer 1994; Andrews and Kappe 1994).

A development that may be critical is 'bandwidth on demand'. What this means is that it will be possible to adjust bandwidth so that teleconferencing could use sound or video or computer graphics or text as they best fit the pedagogical needs of a teleclass. This would mean paying only for the bandwidth used rather than for the bandwidth that is made available as at present.

It would encourage a rational parsimonious approach to media selection. Video would be used when it was needed, not because it was there. Multimedia systems on computers make it possible to have variable video where image quality and frame speed are adjusted for transmission. We can accept low definition images of people talking, but if too many frames of video are removed the jerkiness of the image becomes distracting. By contrast, when the subject is a new surgical technique, high definition of the images may be critical, though what happens may be clearer when seen at only a few frames per second.

When the various aspects of telelearning are seen as a whole they have all the elements of a total educational system. Is this the emerging outline of a comprehensive telecommunications-based alternative to the transport-based classroom system of education? Does it have the communication capability to interlink the four basic ingredients of instruction at a variety of levels and allow for the shifts in fractal levels which are characteristic of the educational process? To test this John Tiffin and I outline, in our book a total telelearning system for the telecommunications environment of the mid-nineties (Tiffin and Rajasingham, 1995: 118-124).

THE VIRTUAL CLASS TODAY

Information technology is already widely used in education and training. Computer-assisted instruction, computer managed instruction and the use of computer simulations for training goes back to the sixties. Audioconferencing has been used since the seventies and instructional television has been tried around the world since the fifties. It is, however, the coming together of computer and telecommunications technologies that could lead to the virtual class as the primary or complementary loci of learning in society.

New information technology such as audiographic and videoconferencing allow synchronous and asynchronous learning. No matter where the learner is they can interact at any time with the teacher, the instruction and with other learners using the written word, the spoken word and still and moving pictures. In the late 1990s, advancements in information technologies such as virtual reality and multimedia would allow fully immersive, interactive, realtime communications through audio, textual video and even touch and smell. This kind of development would create a communications environment where all the functions of a conventional classroom can take place (Tiffin and Rajasingham 1995).

How is it possible to have the effect of a class without the reality of a classroom? A classroom is a communication system that makes it possible for a group of people to come together to talk about something they want to learn, and to look at pictures and diagrams and text that help them understand. The question is, can information technology provide an alternative communications system for learning that is at least as effective?

The idea of a virtual class is that everybody can talk and be heard and be identified and everybody can see the same words, diagrams and pictures, at the same time. This calls for the use of telecommunications and computers. At its simplest, it can be done using two conventional telephone lines at each site, one to link telephones and one to link computers. One line is for sound, and one is for pictures which can be generated on the video display unit (VDU) of a computer. To link more than two sites, a teleconferencing bridging system is also needed. Teleconferencing bridges can be linked to other teleconferencing bridges and theoretically there is no limit to the number of places that can be linked, or where these places are. This is one technology that makes a form of virtual class possible today and there are pilot projects taking place in many countries which show that it can be made to work at least as effectively as a conventional class. Such projects make it possible to think about what a virtual class could be like in the future, as telecommunications systems improve. In time it will be possible to use the public switched telecommunications system to transmit high quality digital sound and high definition video images. Audiographic conferencing systems are being upgraded to include videoconferencing. Not only is it possible for everybody in a virtual class to talk to each other, they can also see each other. We can expect, through the nineties, a rapid development of teleconferencing technology and attempts by the teaching world to adapt it for educational purposes.

THE VIRTUAL CLASS TOMORROW

Just as the telephone can provide televirtual voices, so teleconferencing can provide the effect of a meeting without people actually meeting and is already being adapted for instruction and called a virtual class. However, a new technology is emerging in the nineties called virtual reality. It seeks to create the effect of actually being inside a simulated reality.

The critical enabling technology for the future virtual class is computer generated virtual reality (CGVR).

Computer generated virtual reality (CGVR)

The origins of the computer lie in attempts to represent in numbers the reality of a country's population (Austin 1982). For example, economists try to model economies and depend on the capability of computers to store and manipulate large bodies of data. Physicists use computers to model the physical world. Linguists use it to model languages quantitatively. Content analysis in communications studies uses computers to compare the virtual worlds of mass media with the real world. The computer is a virtual reality generator but with a difference. It is evolving.

Aeroplanes, motorcars and fridges are technologies that have developed, but have not evolved. There is a big difference between a modern airbus and the first flying machines, but they still do the same thing, only faster, further, higher and with more people. They have not evolved into devices that can turn into buses and do the difficult bit between the airport and the traveller's final destination. Nor have motorcars evolved so that they are also flying machines, or fridges so that they can alternate as stoves.

Computers, by contrast, have a historical evolution which seems almost biological in the sense that they acquire new functions but still retain older functions. Personal computers (PCs) have a numerical keypad and can be used as calculators, a link to their genesis as a device for doing sums. They have taken over the role of a typewriter and are beginning to subsume those of television and video. In doing this they have also absorbed associated technologies. The PC is doing to communication what the supermarket did to shopping. It is putting everything that is needed in one place, offering choice and making it easy to access. Word processors now have dictionaries and thesauruses. Spell checkers are an adaptation of one of the functions of dictionaries with the added benefit that they will check spelling mistakes the user was not aware of and build up a user's own list of words, acronyms and spellings. Pagemaker software and the new generation of printing machines subsume printing. Compact disk technologies are now incorporating library functions into PCs.

To begin with, computers were number crunchers, then they became devices for processing written words and diagrams. Now they are acquiring the ability to process images and sound and to recognise and synthesise speech. We can talk with them and link video cameras and microphones to them, scan in images and digitise them. Then we can manipulate the images. We have in the personal computer created an extraordinarily flexible multi-functional communication device which is now beginning to develop its own unique communications functions. The PC can be used for writing, painting or computing. It can also be used for the totally new forms of communications such as multimedia and virtual reality.

Besides the growing complexity of their communications capability, computers are also evolving ergonomically. They are shrinking and becoming more widely distributed and available. From being rare, remote, hugely expensive and inaccessible devices locked away in their own rooms, they became widely available on desktops. From the desktop where they pretended to be a television set on top of a typewriter, they disguised themselves as briefcases called laptops. Now they have shrunk to a point where the metaphor is a book. What will be the next metamorphosis of the personal computer? Will it take on and subsume the function of a pair of glasses? If so, this could be the point at which virtual reality is integrated into the PC. It could even become the basic default mode. Imagine booting up your PC and finding yourself in a virtual reality where you can ask for such functions as a word processor, paintbox, games and school. Just as 'windows' is a metaphor for paper on a desk, the default virtual reality could be a metaphor for a room in which you keep your shelves of books, where you can read, or dictate a letter, send a fax, look at a video, paint a picture, listen to music ... or decide you wanted to be in another scenario. At the moment CGVR is an experimental computer peripheral. Will it become a central function like the VDU and the keyboard in the current incarnation of the PC or will it hang around as an optional dangling appurtenance like printers do at the moment?

Film and theatre are immersive VR technologies. By darkening a theatre they seek to minimise the presence of physical reality. This is a direction that CGVR seems to be taking; to minimise, and ultimately to replace, stimuli from physical reality. It is as though previous VR technologies were to gradually combine and come closer and closer to a person's proximal sensory apparatus, until they overwhelm it and supply the totality of their perception. Think of how a television receiver stands in a room as part of the environment. Then think of how its sister device, the computer video display unit (VDU) sits a foot or so from the person who uses it and dominates their vision. In today's computer-generated CGVR, the most common mode is a head mounted display (HMD) unit which places two small VDUs directly in front of the user's eyes. These are designed to give a stereoscopic image and over sixty degrees of vision, so that what the person sees is three dimensional and fills their total vision. What is visible in the real world is blocked out and replaced by what is visible in a virtual world. Of course the unwieldy HMD and the low-quality graphics remind the viewer that this is an artificial situation, but optical systems are becoming simpler and lighter and if they take the form of spectacles will be something that people are not conscious of wearing. The development of high definition television is likely to impact on the quality of VR graphics making the image more convincing. There is research into the possibility of retinal imaging, which uses lasers to stimulate the rods and cones of the foveal area of the eye to scan images directly into the visual proximal receptors of the human nervous system (Sherman and Judkins 1992: 52). In this case the images could be more intense and defined than those from the real world which have first to traverse and be adjusted by the lenticular system of the eyes with its various imperfections.

What is especially convincing in CGVR is the impression of being inside a virtual reality and being able to look around in it. This is achieved today by a head mounted display (HMD) and a position tracking system which provides information about head position to a reality engine in a computer. The reality engine relates the coordinates of the position of a person's head to a virtual reality so that it can generate an image that matches the point of view of the eyes and transmit this via a cable to the video screens in the HMD. This cybernetic reaction has to be done with a speed that deceives the human perception system into accepting the changed point of view as though it naturally followed from the head movement. The presentation of virtual reality as a wraparound phenomenon depends for its detail and credibility on computer processing speed and memory.

Bit by bit we enter the alternate world of CGVR. First we put our heads in so that we can see and hear virtual worlds. Then we put on a dataglove and waft it about in virtual reality as a disembodied token hand that can interact with the virtual environment. It can pick up virtual objects and move them and allow the user to navigate through the CGVR with special gestures. Next we give the hand feeling with force feedback so that it becomes a tactile glove. Soon there will be two touchy-feely hands and feet in VR. But what promises to make the biggest difference is the datasuit. Wearing one we will be able to venture our whole body into the worlds of CGVR.

Think of the datasuit as a second skin which eliminates the stimuli from the real world and replaces it by stimuli from a computer. What is felt and touched now corresponds to the computer generated sounds and sights. Fibre optics that extend like a nervous system through the datasuit are joined together in a cable that links the suit and the HMD to a computer. One day in the future this umbilical cable will be cut. The growing miniaturisation of computer processing capability, combined with the development of parallel processing, means that the computer generating the virtual reality will be part of the suit. Eric Drexler in his book Engines of Creation (1990) described how, with nanotechnology, a space suit could be designed in the future.

CGVR is part of a cluster of technologies that are drawing together to form the communications infrastructure of the information society. In so doing they will also form the infrastructure of education in the information society. Broadcasting and computers have been impacting on education for some time. Telecommunications is having a growing impact in the nineties. CGVR seems set to enter the field of education at the onset of the second millennium. At this point the combined effects of these technologies could acquire critical mass that would make possible virtual classes in virtual schools, colleges and universities in the fullest sense of the concept as an alternative to the classroom. The history of education in the second half of the nineteenth century shows that when new technologies are applied to education by themselves they are absorbed into the existing educational model. They do not change it. What we are looking at here is the possibility of radical change. Schools and classrooms are likely to continue providing community education for social and physical skills. The majority of academic study, however, will be conducted via an interface device that could look like a pair of spectacles to begin with, but may develop as a datasuit.

We make the assumption that it will be possible to co-mingle the communications functions already subsumed in multimedia PCs with virtual reality and with access to broadband telecommunications networks and we use the acronym CGVR to refer to this triple capability.

Earlier in this monograph I examined the intermediate situation. Today where some students may have their own PCs and modem and access to Internet, some may be able to access telelearning through a telecentre or some educational institution, but all students are still using pen, paper and texts. Now we imagine the day when some students who can afford it may buy books and use paper and pen, but all students will use CGVR as a matter of course and have the kind of symbiotic relationship with it that they have with their clothes. They will wear the technology without thinking about it. The effect will be to make education available anywhere, anytime.

We argued that education in its many guises requires an intermeshing of four factors: teaching, learning, problems and knowledge.

How can these factors be intermeshed at different levels when the communications system of education is based on CGVR. The levels addressed will be: the autonomous learner, the individual learner and teacher, the small group and the large institution.

LEVEL 1 : THE AUTONOMOUS LEARNER

If learning is to be lifelong in the next millennium, then education has to be delivered at the learners' convenience in terms of mode, time and place.

The application of CGVR to the autonomous learner illustrates possibilities of the symbiotic relationship of the technology with the individual. For example, the possibilities of an electronic book become available with CGVR technology used as a reader for disabled people and those whose eyesight is failing. Gaze sensors which use a reflected infrared beam to detect exactly where a person is looking can register the word a person is reading and the size of letters could be adjusted by the reader. Verbal commands such as 'Meaning', 'Pronounce', 'Encyclopaedia', would produce the information needed. If a person's eyes became tired they could simply say 'Read'. The infobahn technology that can download video programmes can deliver the full text of a book in seconds. Libraries will be able to make their collections available for immediate delivery as full text. The house-bound, bed-bound, institutionalised and imprisoned will only need to say 'Library', 'Catalogue', 'Subject', 'Browse', 'Download', to access the world of print. The same of course would apply to libraries of photographs, pictures, videos and films. Multimedia already does this and CGVR will subsume multimedia. In so doing it could improve them by adjusting the presentation to each ear and eye of the individual. Aside from providing lifelong learning opportunities, these technological advances could enrich the existence of people partially disadvantaged in hearing and sight.

Learners need to be able to access existing knowledge in conventional media in CGVR. However, CGVR as it develops also opens the prospect of being able to generate models of phenomena that are more explicit than anything we have had before. Such models could show movements and relationships that would be difficult to describe in words and numbers or with conventional diagrams and photographs. It would be possible to study models from any angle, from macro and micro perspectives, from within and without, in part and in whole. Such virtual reality models would seem particularly suitable to the representation of examples from a problem domain when these are real life phenomena that are particularly difficult to demonstrate or show because of their size or the danger involved.

In real life, problems like soil erosion are not usually waiting in all their manifestations somewhere convenient to be studied. Their dynamics are difficult to study because they often take place in extreme weather conditions or are too slow for human perception. The creation of virtual landscapes from case studies of erosion would make it possible to analyse stages of erosion at macro and micro levels. A learner could ask to see the data from the case studies on which the simulacrum is based. It could appear as a window to one side of the virtual reality. The learner could vary the relationships between data from the original study on such aspects as slope angle, rain levels, wind speeds and directions and watch the virtual landscape change accordingly. It would be possible to take a distant macro perspective while windowing aerial photos or a map or even a page of text to help interpret what is seen. Then the learner could zoom in to a micro-perspective of soil horizons exposed in gullies asking at the same time to see diagrams and photographs of different kinds of soil and the changes that could take place in them. Conventional two dimensional media could be expanded to fill the learner's vision, or they could appear in a two dimensional window in a three dimensional perspective. This is what we do when we hold a map while we orientate it against a landscape or spread it out and bury ourselves in its detail. What would be different in CGVR is that when we see something of interest in the map we can then call it up and move through the map into a three dimensional virtual reality (Tiffin and Rajasingham 1995: chapter 7).

This pattern of slipping between two dimensional conventional information and three dimensional CGVR is not dissimilar from the way our perception of the real world shifts subtly between two and three dimensions. The two dimensional door of a classroom becomes three dimensional when it is opened. Walk through it into the three dimensional classroom where much of the instruction will be conducted on a two dimensional whiteboard. Pick up a three dimensional book, open it and read from the two dimensional pages which become three dimensional as you turn them and whose flat surface under a microscope may look like the Himalayas. CGVR has the capacity to serve as a conventional two dimensional surface and mimic a page, screen or blackboard, but such a screen can also have the Alice through the looking glass quality of being a portal to a three dimensional world. This attribute of CGVR has the potential for presenting information as a network in a way that is foreshadowed and experimented with in today's distributed multimedia systems. It will allow a person to navigate knowledge and explore environments in a way that is unprecedented.

If CGVR can provide instructional resources in two dimensional as well as three dimensional form, and can do this at the convenience of the learner, then it will make education available to many people for whom it is now inaccessible. Whatever shape the interface takes whether a pair of spectacles, a head-mounted display unit or a datasuit, it should be like an automobile to the learner giving them the kind of freedom that a car gives to the traveller. Freedom from timetables, fixed ways of doing things and restrictions on destinations. They can go where they want, when they want, provided they can afford the costs.

LEVEL 2: LEARNER AND TEACHER

This is the dyadic teacher/learner situation which is powerful because of the focused way it pulls together the four factors; teaching, learning, problem and knowledge. It is there in the classroom as everyone is working on a problem and a hand goes up, or when a teacher helps an individual in difficulties, or goes through an assignment with a student. The autonomous learner outside of a classroom manages, but there will often be a time when they want to put their hands up and get help. Most PC applications have an instructional manual and a help function that will provide computer-assisted instruction. The computer presents the problems, the help function provides the knowledge needed to solve them. Nine times out of ten it works. The tenth time, however, the autonomous learner pores over the manual and the help function in growing frustration. They need a teacher rather in the way that they need a doctor. Just as the autonomous learner wants just in time knowledge, they also need a teaching emergency service. CGVR should be able to offer two such services: one with human teachers and one with teaching entities derived from artificial intelligence (AI): virtual teachers.

Learning with virtual teachers

The term AI is loosely used about computer applications which in some way resemble the application of human intelligence. We are not making the case that one day a computer will replace a teacher. We are simply looking at a trend that has been observable in the second half of this century. It began with the automation of some of the tasks done by teachers. This can be seen in 'teach yourself' books, language labs, teaching machines and computer-assisted instruction. It is a trend that is typical of the development of an information society. Just as automatic telling machines automate some of the functions of a bank teller, so computers can automate some of the simple repetitive functions of a teacher. As students acquire their own personal computers there is no reason why these cannot be used to do simple instructional tasks. All teachers correct spellings and there can be few who enjoy the task. It has little effect as the feedback is too delayed. Doing this must cost millions of teaching hours per year. A wordprocessor that questions dubious spellings as a student keys them in provides more effective feedback. This frees teachers to do the things that really do need human intelligence and compassion.

The just in time teacher

It would be a boon to an autonomous learner if they could get a human teacher when they needed one. Increasingly that is likely to be when they are trying to solve a real life problem with what they have learned and find it is not as straightforward as the instruction implied. One of the great strengths of the classroom system is that a learner has only to put their hand up to get a teacher's attention. The trouble is that this is only possible during class time. There is also the simple fact that some learners are uncomfortable with some teachers and do not in consequence learn from them.

What is needed is a network of teachers that makes it possible for learners to find the teachers they need when they need them. Instead of having to sign on for a course that approximates to what the learner wants to learn and travel to be taught in a classroom by somebody nominated by an institution, the learner can select the teacher they want, meet with them in telepresence and focus the instruction on their specific needs. There need be no restrictions in the distance to be travelled to meet a teacher. A learner can have a teacher in telepresence from anywhere in the world. Just as learners can be anywhere, so too can teleteachers. They can live where they want without the pressures of travelling to work or of conforming to the ideas and methods and timetable of an institution.

Teleteachers can advertise as part of an IVANS (international value added network service). They would make their living by virtue of their professional skills, with the world their market. We could imagine some of them as general teaching practitioners ready to diagnose basic learning needs and help where these were within their competency, but also being able to guide people to more specialist teachers when that was appropriate. Learner and teacher meet as telepresences in a televirtual reality with the problem under study lying in the space between them. Anybody who has ever acquired a computer knows the need they have at times to get on the telephone to someone and ask how something is done and the difficulty they then have in not being able to show the problem or see the solution.

LEVEL 3: THE SMALL GROUP

Sometime in the first decade of the next millennium it will be possible to generate a virtual version of the kind of classroom we are all familiar with. Students and teachers will be able to sit and talk with each other in telepresence and use a whiteboard or watch slides or films or read books and write as they do today in conventional classrooms. If the classroom as we know it is the best locus for learning that we can think of, then we will be able to recreate it, endlessly, without a building program. Nobody has to travel to get to it and when it is not in use, it can be turned off. This, in itself, means that the idea of a computer-generated virtual class represents a solution in the near future to the problem of finding classrooms to accommodate the gigantic expansion of education predicted for the next century.

Will we really use CGVR simply to replicate the existing learning system that the conventional classroom supports, or will we use it as an opportunity for a paradigm shift in education where we rethink and redesign learning systems in their entirety? New technologies often begin by imitating the appearance of the technology they seek to supplant. The shape of things to come is in the popular imagination seen in terms of the existing way of doing things. Educational television in its early days essentially took the form of a televised teacher giving a lecture. The presentation part of a lesson was enlivened with smart graphics and film or video inserts, while the untidy interactions of a classroom were left out. ETV mistook form for function. Will a televirtual classroom simply be an electronically generated simulation of what we have now?

Conventional classrooms are built to last and are not easily changed. Creating a room with four walls and a whiteboard and some desks is an elementary exercise for a CGVR authoring system. It is difficult to think that when teachers and learners can select and adjust the place where they learn, that they will remain with images that evoke the classic classroom. Form in CGVR is infinitely malleable. The real challenge to the instructional designer of the future will be in adapting the functionality of CGVR to the functionality of instruction without the mindset of the conventional classroom.

Today, prototypes can accommodate three people at the moment, but researchers like ATR's Nobuyoshi Terashima says that in the future there will be no limits to the numbers who can meet in telepresence. A successful teleteacher who has a number of telelearners might suggest that they meet synchronously as a small group for a teletutorial or as a slightly larger group for a teleseminar or even larger group for a teleclass.

VR technology is a computer technology and can be linked to telecommunications systems. This is how it works. One person sits in front of a screen and puts on a pair of glasses and a glove. This makes it possible for them to interact in a virtual room with another person who is sitting in front of a screen in another place who has the same equipment. They are linked by telecommunications. They see each other apparently sitting around a table in a conference room. They are actually looking at computer graphic images of each other, but the image is three dimensional and their faces move as they speak. At the moment it is possible for three people to meet in this way and see each other in three dimension and have a discussion. They can also use their gloved hand to manipulate virtual objects within the virtual room or to change the virtual scenario. There is no technical reason why this virtual teleconferencing system should not be used for a virtual class. It can be done now. However, today's VR technology is where radio technology was a hundred years ago. It is at the very beginnings of its development and adoption for popular commercial applications.

The teachers and the other students a learner meets as telepresences in CGVR are unlikely to be the same people as those a learner meets in a conventional school. What draws them together is that they have a common interest in a subject rather than the accident of living in the same schooling zone. Rheingold argues that virtual communities develop their own cultures (Rheingold 1993). They could be very different people from very different backgrounds and places, but this does not have to be apparent because they meet as telepresences. They can choose to be who or what they want other people to think they are. Perhaps in a virtual orchestral class learners will present themselves as their musical instruments or in a virtual history seminar as personages from the time under study.

There is no need for learners to be together through the day in a CGVR class. The system is flexible. Learners can study autonomously, they can study with a virtual teacher, they can study together as pairs or in small groups. Teachers can join them as telepresences for one-on-one tuition or teachers and learners can meet as a group in a virtual class. What we see here is a technology that can address the fractal levels in learning. A learner can use the technology to slip between levels. They can act as their own teacher or they can get help from an artificial teaching entity. If this is not working or if they prefer to learn with other people, then the learner can shift levels and work with a peer or teacher to intermesh the four factors of instruction. Or they can move up to yet another level of complexity and try to intermesh the four factors with a large group of learners and teachers. In a televirtual class this may mean trying to intermesh the teacher, learner, problem and knowledge factors with a variety of people from different places, different countries, different cultures who have in common an interest in learning how to apply knowledge to a particular problem domain, but approach it from different perspectives. We could at this level be looking at very large numbers of people indeed and an intermeshing of teachers, learners, problems and knowledge at levels of complexity beyond anything that currently exists in conventional educational and training systems.

LEVEL 4: THE LARGE INSTITUTION

Carl Eugene Loeffler is Project Director of Telecommunications and Virtual Reality at the Studio for Creative Inquiry in Carnegie Mellon University. He is building a virtual city on Internet . He calls it the Virtual Polis. To access it from Internet will require an HMD unit and some special software. Theoretically it could be a virtual megacity accessible to millions of people. It is a three dimensional networked virtual reality with high rise buildings, private domiciles and a park. You can move about in it as a telepresence and meet with the telepresences of other people. You can buy a plot and build a virtual house or rent or purchase existing virtual houses, apartments or shops. You can set up your own business and advertise it ... on virtual billboards. Shopping and entertainment, as in any metropolis, are seen as major functions that will attract a lot of people. Carl Loeffler is a visionary who sees his Polis as having many aspects. It could be viewed, he believes, as a graphic user interface (GUI) for home based electronic shopping and entertainment. He also sees it as an experiment in tele-existence. If so, then it will need a university to research and teach what is learned in tele-existence about tele-existence. Beside the park to one side of downtown Polis there could be spires and a clock tower that indicates there is a university. The university of tele-existence (UTE) is described in our book (Tiffin and Rajasingham, 1995: 157-160).

We are beginning to conceptualise virtual reality as a new medium and come to some appreciation of its possibilities. These are extraordinary. We appear to be facing in communication the kind of quantum change that Eric Drexler (1990) predicts for manufacturing with nanotechnology. Applications of virtual reality are being developed in such fields as architecture, medicine and arcade games. However, its origins were in institutions, in the development of flight simulators for training (Rheingold 1991: 203). It is time to see how it could be applied to education and the development of virtual classes in the fullest sense as wraparound environments for learning where students as telepresences can see hear, touch and perhaps one day even smell and taste.

What will be possible with virtual reality fifty years from now? What form could a virtual class take? What potential capabilities could it have? Is a virtual class likely to be an improvement on a conventional classroom as a communication system for learning in the coming information society? Will it be the place where our children and their children learn to learn? What will be possible with virtual reality fifty years from now?

Finally, will our grandchildren's school uniform be similar to Learner 2000's uniform-datasuit, helmet and gloves- or would they only need a pair of spectacles or even just some contact lenses or perhaps a mere whisper?

I conclude with the words of Bernard Shaw:

> "... imagination is the beginning of creation. You imagine what you desire; you will what you imagine; and at last you create what you will." (Shaw, Back to Methuselah Part I Act I).

And so the search goes on.

REFERENCES

Altbach, P. G. (1985). The great educational crisis. *Excellence in education: perspectives on policy and practise*. Buffalo, Prometheus Books.

Andrews, K. and F. Kappe (1994 (June)). *Soaring Through Hyperspace--A snapshot of Hyper--G and its harmony client*. Eurographics Symposium and workshop on multimedia, Graz, Eurographics Symposium and workshop on multimedia.

Austin, G.D. (1982). Processing. *Herman Hollerith: Forgotten Giant of Information Processing*. New York: Columbia University Press.

Bigum, C. and B. Green, Ed. (1992). *Understanding the New Information Technologies in Education: A Resource for Teachers*. Geelong, Centre for Studies in Information Technologies and Education, Deakin University.

Coombs, P. H. (1968). *The World Educational Crisis; A Systems Analysis*. New York: Oxford University Press.

Coombs, P. H. (1985). *The World Crisis in Education:The View From the Eighties*. New York: Oxford University Press.

Drexler, E. K. (1990). *Engines of creation*. London: Fourth Estate.

Drexler, E.K. (1992). *Nanosystems: Molecular Machinery, Manufacturing, and Computation*. New York: John Wiley and Sons.

Gooler, D. D. (1986). *The Education Utility: The Power to Revitalize Education and Society*. Englewoods Cliffs, NJ: Educational Technology Publications.

Heinich, R., M. Molenda, M. and Russell, J.D. (1985). *Instructional Media*. New York: Macmillan.

Holmberg, B. (1982). *Essentials of Distance Education*. Hagen: Fernuniversitat: ZIFF.

Holmberg, B. (1983). *Guided Didactic Conversation in Distance Education*. In D. Sewart, D. Keegan, & B. Holmberg (Eds.), *Distance Education: International Perspectives*. New York: St Martin's Press.

Marginson, S. (1993). *Education and Public Policy in Australia*. Cambridge, U.K: Cambridge University Press.

Maurer, H. (1994, July). *Advancing the ideas of the World Wide Web*. Hypermedia Conference. Auckland: New Zealand.

Moore, M. G. (1973). *Towards a Theory of Independent Learning and Teaching*. Journal of Higher Education, Vol. 44.

Rajasingham, L. (1988b). *Distance Education and New Communications Technologies*. Wellington, N.Z: Telecom Corporation of New Zealand.

Reich, R. (1991). *The Work of Nations: A Blueprint for the Future.* London: Simon & Schuster.

Rheingold, H. (1991). *Virtual Reality.* New York: Simon & Schuster.

Rheingold, H. (1993). *The Virtual Community.* Reading, MA: Addison-Wesley.

Rossman, P. (1992). *The Emerging Worldwide Electronic University: Information Age Global Higher Education.* Westport Ct: Greenwood Press.

Russell, B. (1925). *ABC of Relativity*). London: Allen & Unwin.

Shannon, C. E. and W. Weaver (1949). *The Mathematical Theory of Communication.* Urbana: University of Illinois Press.

Shaw, B. (1922). *Back To Methuselah.* London: Constable & Co.

Sherman, B. and P. Judkins (1992). *Glimpses of Heaven, Visions of Hell.* London: Hodder and Stoughton.

Terashima, N (1995). *HyperReality.* In Proceedings Of the International Conference on Recent Advances in Mechatronics, ICREAM '95. Istanbul: ICREAM

Tiffin, J. (1976). *Problem Structuring in ITV systems in Latin America.* PhD Thesis. Florida State University.

Tiffin, J W and Rajasingham, L. (1995). *In Search of the Virtual Class: Education in an Information Society.* London: Routledge.

UNESCO (1993). *World Education Report 1993.* Paris: UNESCO.

Vygotsky, L. S. (1962). *Thought and Language.* Cambridge, Mass: M.I.T Press.

Vygotsky, L. S. (1978). *Mind in Society: The Development of the Higher Psychological Processes.* Cambridge, Mass: Harvard University Press.

Woods, B. (1993). *Communication, Technology, and the Development of People.* London: Routledge.

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