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SYNCHRONOUS TWO-WAY COMMUNICATIONS TECHNOLOGIES: TECHNOLOGY AND PEDAGOGY

Distance education has operated in several somewhat separate technological worlds. These can be summarized as primarily broadcast, or one-to-many, technologies such as television and print, asynchronous online teaching through the Internet and the World Wide Web, and synchronous, two-way technologies, such as audio- and video-conferencing. This chapter will focus on the potential and limitations of synchronous or 'real-time' two-way telecommunications technologies for teaching and learning.

In this chapter four related two-way synchronous technologies will be discussed:

- audio-conferencing using standard telephone services,
- narrow-band video-conferencing using standard or ISDN telephone services,
- broad-band video-conferencing using high-speed networks (fibre-optic and/or satellite)
- conferencing over the Internet (Web-conferencing or IP-conferencing).

Although there are significant differences between each of these technologies, there are also many common educational features. When talking then about common features of these four technologies, I will use the generic term 'tele-conferencing' (recognizing that in the past, 'tele-conferencing' was also used for to describe any one of the single technologies).

As well as describing the development and applications of these four technologies, the chapter discusses the role or place of tele-conferencing technologies in modern distance education. Are synchronous tools really necessary in distance learning and in particular online education? Do synchronous methods compromise the individualized or flexible study models favored by many distance educators? In what new ways do web-based synchronous technologies, such as web conferencing, improve earlier forms of telecommunications-based instruction?

THE TECHNOLOGY

In the last fifty years there has been phenomenal development in telecommunications technologies that support real-time, two-way communication. This real-time nature is often referred to as synchronous communication. A good example of a synchronous two-way communications technology is the telephone, an invention of Alexander Graham Bell. An educator as well as an inventor, Alexander Graham Bell

dreamed of bringing the wisdom and knowledge of great thinkers into ordinary people's lives through the use of technology. He is credited with developing an early form of radio-telephony, called the electrophone, which became widely popular both as an entertainment and as a communication device (Farley, 2002). The electrophone continued to be used until the invention of the radio early in the twentieth century (Gallagher,1999).

INSERT FIGURE 1 ABOUT HERE

Audio-conferencing

Audio-conferencing is a development of telephone technology. Audio-conferencing is still found in some distance education programs. Audio-conference services can be booked through private companies offering teleconferencing services for a fee or through an internal service if the institution owns its own bridge.

Audio-conferencing can be used either with individuals in their homes or offices, or with groups in local centres, such as a satellite campus. For individual learners, the instructor calls a phone number to connect through a conference bridge, a special telephone switch that allows several lines to be shared at the same time, so all users can hear and

speak to each other in real time. The student needs no special equipment other than a standard telephone. The second kind of audio-conferencing, group conferencing based on one or more remote sites with several students at each site, requires more sophisticated equipment. This may include loudspeakers, microphones that are button-operated by the student when they want to speak, or an omni-directional microphone that can pick up speakers in different parts of the room.

Early teaching through audio-conferencing was cumbersome, since participation was restricted to one speaker at a time, and line quality was often poor. These were strong disincentives for free-flowing and spontaneous discussions. More recently full duplex systems and digital telephony have eliminated noisy lines, fading and disconnections to the extent that an audio-conference call should now be free of technical difficulties.

A limitation of audio-only conferencing is the lack of visual contact between students and instructor. Careful design, planning and presentation are needed to overcome these constraints (Wolcott, Napper and Lindsay, 1994). Consequently, computer-based audio-graphics were developed and combined with two-way audio. The instructor and students were able to transmit and view whiteboard or computer graphics, including annotations, in real time. This type of application

was well suited to the teaching of science, mathematics and other subjects requiring two-way graphical interaction (Moore and Kearsley, 1996).

Audio-graphics have been used in Australia in the K-12 sector for second language learning (Oliver and McLoughlin, 1997). Participants were connected by telephone for audio interaction and by computer, either over telephone lines or the Internet, for viewing visuals and graphics and making annotations. While learners found the lessons engaging, few instructors took advantage of the audio graphic tools. At the Universiti Sains Malaysia in Malaysia, audio-graphics were used to address a shortage of qualified tutors and to improve the quality of instruction at remote locations. Tele-tutorials were used in conjunction with print based self-instructional packages. Outcomes included a higher quality of live instruction than provided previously face to face (Idrus, 1993).

However, although Filcher and Johnstone (1989) found that audio-graphics teleconferencing was superior to correspondence study and audio only teleconferencing, they (and Wilcox, 1994) also found that learning environments based on two-way audio plus electronic white boarding could result in miscommunication and anxiety in learners. Filcher and Johnstone also found that although the graphical capability provided the potential for enhanced two-way interaction, learners

generally rarely touched the tools due in large part to the design parameters imposed by the instructors. The biggest advantage cited by learners was the social and collaborative benefits, which resulted from attending sessions with other learners (Oliver and Reeves, 1996).

Audio-conferencing has diminished as a distance delivery tool, partly due to alternative forms of distance delivery such as video-conferencing (Hardy and Olcott, 1995), and web based solutions. However, some useful lessons have been learned from the experience of using audio-conferencing and audio-graphics for teaching that will also apply to the newer technologies of conferencing.

Narrow-band video-conferencing

Early development of video-conferencing technology was carried out in the 1920's by Bell Telephone Laboratories, the research arm of AT&T, and aptly, the same company founded by Alexander Graham Bell in 1877. Bell Labs initiated the first live video-conference in 1929 between Washington and New York City (Newton, 2002). The New York Daily Mirror reported that the audio was clear and the video 'inoffensive' (Rosen, 1996). Despite the success of the trial, it would still be many years before two-way video and audio communication would be commonly available.

In 1964, AT&T, taking a leap of faith, unveiled the world's first personal conferencing system, or PicturePhone. Despite its sophisticated engineering, there was no installed base of PicturePhones to connect to, and analogue telephone networks were not capable of supporting high bandwidth applications. Although the idea of a picture phone was set aside, it was not abandoned. In 1974, AT&T opened the first commercial Picture Phone videoconference service in the United States. Despite offering twelve locations, the system did not become popular. A study commissioned by NASA in the late 1970's identified three main obstacles to video-conferencing at the time: the high costs of equipment and facilities, the lack of interoperability between different vendors products, and user resistance: people still preferred to meet and conduct business in person (Trowt-Bayard, 1994).

Thus although 'one-way' satellite and broadcast technologies were used extensively by educators in the 1970's and 1980's, two-way video-conferencing did not start making significant headway until the early 1990's (Boaz, Elliott, Foshee, Hardy, Jarmon, Olcott, 1999). The big break-through for telephone-based video-conferencing was compression technology. Video and audio signals can be originated in either analogue or digital format. Analogue signals can be converted to digital signals, and vice-versa, by using encoding and decoding equipment (known as codecs). Both analogue and digital signals can be carried by any

medium, such as satellite, fiber optics, or even telephone cable, provided that the transmission and reception equipment uses the same format, or that there are codecs for conversion. Thus, for a digital television signal to be received on a standard analogue domestic television set, somewhere between origin and reception the signal must be converted, compressed and transported.

One way to reduce the bandwidth required for transmission, and hence costs, is to 'compress' the video image, that is, to digitize the signal and then to remove as much extraneous or redundant data as possible. Although a full-motion analogue television picture changes 30 times per second in North America (25 times per second in Europe), not all of the picture changes in each frame. For instance, with a 'talking head' against a still background, probably less than 10 percent of the picture changes from frame to frame. Once the basic picture is captured, all that needs to be transmitted per frame are the changes. It follows that the more movement, and the faster the changes, the more difficult it becomes to compress without losing quality. Similarly pictures transmitted at narrow band rates tend to be jerky and have problems with lip synchronization. Compression technology is changing rapidly. Engineers are developing more and more powerful algorithms for converting from analogue to digital, allowing increasingly more data to be compressed without noticeable differences in the quality of the picture.

A telephone-based video-conferencing system is likely to include a camera, and two video monitors, one showing the 'active' connected remote site and the other the 'home' site. An omni-directional microphone would be placed on a table in the middle of the room, or there would be button-push individual microphones. A document camera would be available to display documents and three-dimensional objects. A computer can be connected to display and transmit slides, Internet sites, or any other computer-generated materials. A self-managed operating console would be used to control camera and other inputs. Possibly some form of sound-proofing and special lighting within the room would also be needed.

The system also requires a codec that converts and compresses video and audio signals for transmission over the standard telephone system, a connection to standard or ISDN telephone lines, and to a Multipoint Conferencing Unit (MCU) if three or more locations are to be included. Telephone-based video-conferencing requires a minimum of two telephone lines operating in tandem (58-64 kbs x 2), although many systems now use six lines (58-64 x 6 =348-384 kbs). Most systems now use a common international standard (H.320) for narrow-band video-conferencing. This enables users to call video-conferencing sites almost

anywhere in the world over dial-up, digital networks, and be able to connect.

For administrators, video-conferencing offers a number of advantages. Similar to setting up a new telephone connection, ISDN is simple to order (in urban areas) and install. Users can choose from two (112 Kbps) to a maximum of six (384 kbps) digital lines. The newer systems require only minor room modifications to optimize audio and video quality. Simple installation, set up and operation mean that instructors and facilitators can be trained to operate equipment. Therefore newer systems represent savings on technical and end user support. Although this is not always welcome from the instructor's perspective, it does mean that 'live' remote classes are possible without a large contingent of technical support personnel.

The availability of national and international telecom-supported sites enhances global connectivity and reach. Peripheral audiovisual equipment enable a wider range of multi-mode communication options. Videos can be played, slides and graphics displayed, computer graphics and web sites accessed. The ability to see whom they are talking to counters instructor resistance in using earlier forms of synchronous technologies such as audio and audio graphics teleconferencing. Video-conferencing can serve a variety of administrative and communication

needs in addition to distance learning, such as meetings, job interviews, and candidacy exams. Lastly, video-conferencing reduces the need for instructors to travel to remote campuses. As Trowt-Bayard (1994) surmises, '...it's easier to move bits than bodies.' (p.12). Correspondingly, it also increases access to on-campus courses, creating a wider market for more specialized courses.

Thus the most popular form of video-conferencing at the time of writing is dial-up telephone-based compressed video-conferencing (although all video-conference systems sold today support both telephone dial up and web supported connectivity). Nevertheless, despite the improvement in compression technology, there can still be some loss of picture quality (jerkiness, blurring of movement), particularly over 58-64 kbs transmissions, although for standard lectures using slides and a talking head, this is not a major problem, especially if six lines are used. It becomes more of a problem if equipment or movement is being demonstrated or high quality video or graphics need to be shown. Hence the increasing move to broadband network solutions.

Broadband video-conferencing

Broadband networks tend to be fully digital and multi-purpose, carrying telephone, fax, data, television and video-conferencing. Where sites are connected through high-speed broadband cables or networks (co-axial or

fiber-optic), then high quality, broadcast standard video-conferencing is possible. For connecting multiple sites at the same time, advanced digital switches are required. Higher quality cameras and equipment can be used. As a result, picture and sound quality tends to be much higher than with narrow-band video-conferencing.

Ontario, Canada, is investing C$78 million (US$54 million) in 3,700 kilometers of broadband optical network (the ORION network) to connect their 43 post-secondary institutions and over 50 publicly funded research institutions. ORION will also connect to Internet2 and other national and international high-speed networks, such as Canada's CANARIE cross-country network. ORION will have wavelength capacities of 10 ghps, scalable to 320 gps capacity. The Indiana Telecommunications Network is another public-private partnership, providing a high-speed network between public institutions across the state of Indiana, allowing users access to high quality within-state video-conferencing and to by-pass public Internet and telephone networks to ensure high speed communications within the state.

Broadband networks require decision-making at government or inter-institutional levels. Governments often make these decisions to ensure that their state or province is not left behind in the information technology race. Initial investment costs are very high and the capital

costs are often paid for at least in part by government, but backbone infrastructure operational costs tend to be transferred to the user institutions and can be substantial. However, since the institution has to pay these costs, irrespective of demand, end users such as academic departments are often offered these services without direct charge, to ensure the technologies are used.

Web-conferencing

Currently this is best described as very narrow-band or variable bandwidth conferencing. This allows users to communicate through their desktop computers in real time. Because of bandwidth restrictions, web-conferencing focuses more on audio, graphical and text communication in real time. Individuals can speak with one another and collaborate on text-based projects using data conferencing tools such as document sharing, white-boarding and chat.

Web-conferencing is more and more integrating synchronous with asynchronous functions, such as video- and audio-streaming, and access to Web sites or PowerPoint slides. The synchronous communications can be archived and accessed later by those unable to attend in real time, or by those who attended in real time but want to review or study the material more closely. Network connectivity is

provided by ISDN, corporate intranets, or the Internet, and is beginning also to be provided through mobile telephony.

Real-time, synchronous video applications are limited in web-conferencing due to bandwidth restrictions. Desktop video-conferencing was the catalyst for the development of products such as CU-See-Me for the Macintosh, developed by Cornell University in 1994, Microsoft's NetMeeting, which was installed with Windows 95, and more recently Centra. However, because of current bandwidth restrictions to most desktop computers, the video is dramatically compressed and usually appears in a small window on the computer screen. Even with a small compressed window, picture quality is currently quite poor. It is not possible at the moment to communicate video from more than two sites simultaneously, although some software allows the instructor to switch between several different sites in sequence. Thus live video is a feature that needs to be used selectively. Audio quality during a web conference can be surprisingly good. However, in most cases audio is half duplex, supporting one speaker at a time, a situation that has much in common with early audio teleconferencing applications.

Current software for managing desk-top video-conferencing and integrating it with asynchronous functions is still crude and tends to give all control of communication to the instructor. Consequently,

applications of this technology for teaching purposes will be quite limited until bandwidth to and from the desktop, and computer processing speeds and compression technology further improve. For these reasons, the current growth in web-conferencing places less emphasis on synchronous video communication.

Despite the restrictions on real-time video, there is growing interest in synchronous web-based conferencing (Barron, 2001). An alternative to expensive and site-restricted technologies, web-conferencing has been seen as the 'next generation' distance learning technology (Gillan and McBride, 2001). Eduventures, an eLearning market research company, forecast that live synchronous distance learning is not only gaining momentum in the online environment, it will soon overtake asynchronous online learning in corporate, government and post-secondary settings (e-Learning News, 2001). The justification for these claims will be examined later.

ACCESS AND FLEXIBILITY

During the 1980s, home access to the telephone system increased dramatically in most Western developed countries. For instance, the number of homes in Britain with a telephone increased from 54% in 1974 to 86% in 1991. Consequently, audio-conferencing was quite extensively used for educational purposes in the 1980s. Robinson (1984)

listed over 60 systems and 170 organizations in the USA alone using educational audio-conferencing. The British Open University was logging between 700 and 1,000 hours of small group audio-conferences in 1982.

Home- or office-based audio-conferencing provides greater flexibility for learners than campus-based audio-conferencing. However, as telephones started to become ubiquitous in most homes in developed countries, video-conferencing and the Internet were already becoming established, and hence home-based audio-conferencing has not been as extensively used as it might have been. Also, we shall see that the costs of home-based audio-conferencing are high. As a result, most educational uses of audio-conferencing, and almost all applications of video-conferencing, have been through campus-based sites, where groups of students could be served.

The advent of video-conferencing led to substantial growth in the number of traditional institutions offering off-campus courses. This method became particularly popular with campus-based US state universities, as these had a mandate for equal access to citizens wherever they were located in the state. Telecommunication technologies enabled institutions with such a mandate to make better use of limited teaching resources, as courses could be taught to larger numbers of learners across the state without instructors having to travel. Thus audio- and video-conferencing

provided greater educational opportunities and efficacy in learning (Duning, Van Kererix., and Zaborowski, 1993).

However, although campus-based group conferencing enables students to access locally programs coming from a distant provider, students still have to be present at a set time and a set place. This reduces flexibility compared with home-based technologies such as mail-delivered printed materials or home-based computing.

Web-conferencing to the desktop (or mobile telephone) promises more flexibility and convenience, especially with respect to more narrow-band applications such as audio, text and graphics. Software and licensing costs though for web-conferencing are relatively high, and this restricts access. The ability to archive and access later synchronous web communication provides added flexibility for those who cannot participate in real time.

With respect to full desk-top video-conferencing, at the time of writing the necessary bandwidth to the desktop is just not there for most potential students, nor are the sophisticated software/interfaces that are needed to make this a user-friendly learning environment. However, this situation is likely to be resolved over time, as wide-band Internet access

becomes available to the desktop, combined with higher performance machines capable of handling high-speed data.

TEACHING AND LEARNING IMPLICATIONS OF CONFERENCING

Early distance learning, based on print-based correspondence and/or broadcasting technologies such as radio or television, was characterized by its distinctive lack of real time interaction between learners and an instructor and in particular learners to learners. Technological solutions were needed that would enable educators to '...reconstruct the learning environment' (Schwier, 1994 p.213).

The development of two-way synchronous technologies enabled a transition from an individual print based model of instruction where the learner studied in isolation, to a more group oriented and distributed based approach. Audio-conferencing was the first conferencing technology to provide two-way capability as a supplementary or a main technology for teaching. As a supplement, it provided interactive support for print- or video-based systems such as satellite television. As a main technology, it supported a wide range of instructional applications, such as tutorials, lectures (Kirby and Boak, 1989), and learner support (Lalande, 1995). Students could still study from home but in a real-time group context. With video-conferencing, learning could take place

synchronously at local study centers or at university or college satellite campuses (Collis, 1991).

There are a many different synchronous solutions on the market today. However, Web conferencing usually combines both synchronous and asynchronous features. Teacher and students can interact visually, graphically, and verbally, synchronously or asynchronously. Students can step out of a synchronous session without disrupting the lesson, but still notifying participants that they have left the room. Students can hold conversations on the side, using text chat, or attract the attention of the presenter without having to interrupt. A student can have a private conversation with the presenter/instructor without disrupting the rest of the class.

Students and teacher can share word-processed documents, spreadsheets, and other computer applications. They can access web sites, either as a group, or individually. Students can access multimedia, animated graphics, PowerPoint presentations and recorded events for playback. Students can be assessed through multiple-choice questions and receive immediate feedback of results. Students can also get online instructor evaluation either synchronously or asynchronously. Students can submit questions to an instructor (or the class) live verbally or through asynchronous messages. Instructors can get live polling of

issues and see the results immediately. Thus desktop web-conferencing allows both synchronous and asynchronous learning activities to be combined and integrated.

Modes of tele-conferencing

Figure xx sets out in diagrammatic form some of the most common modes of teaching by telephone or video-conferencing.

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Mode 1: Individual to individual

Mode 1 represents a tutor communicating on a one-to-one basis with a single student. Many distance teaching institutions still use the telephone in mode 1 for individual tutoring and counselling, with print and other media providing the direct teaching. Although today the telephone is rarely used as the main source of teaching, and e-mail provides a less time-dependent mode of communication, the telephone can still provide critically important tutorial support or counselling to students studying at a distance.

To encourage greater student-tutor contact, some distance teaching institutions require their tutors to initiate the first call to students, as there is substantial evidence that students are often reluctant to call tutors. Other institutions set 'office hours', when students can phone their tutors, and know they are available for tutorial advice. Some institutions offer 'call-free' services, where the call is automatically charged to the institution, even if initiated by the student.

Mode 2: Tutor to a single, remote group

Mode 2 represents a teacher or tutor in contact with a group of students at a remote site. This is sometimes used when the teacher is in one institution (and may incidentally have 'live' students before her in a classroom), and the remote group is at another campus, or in another institution. In this mode, it is generally used for direct instruction. It is particularly useful where there is a secondary or 'downtown' campus. No bridge is required in this situation, as only one remote site is connected. This mode can be supported either by audio- or video-conferencing. It is generally used as the main delivery medium.

Mode 3: Tutor to remote individuals

Mode 3 links a tutor or instructor with a number of individual students at individual sites - usually students at home. Through the use of a bridge, every person can speak to and hear every other person.

Currently, this is still limited mainly to audio-conferencing by telephone, although some software such as Centra allows for Web-based conferencing, with a small picture from the site live at the time of the transmission, as well as sound. Because only one site can be 'active' (that is, transmitting), at any one time, it requires skill to manage such conferences. Importantly, control over the design and conduct of this mode of conferencing usually remains firmly with the instructor.

Although technically it is possible to link a large number of sites together through audio- or Web-conferencing, the risk of technical difficulties rapidly increases with more than seven sites. An equally serious constraint is the number of students that can be effectively taught or tutored in this way at any single time. Generally, about seven sites/individuals are optimal for audio-conferencing, and even less for Web-conferencing, if a high level of interaction between teacher and student is to be maintained. Furthermore, we shall see that this mode has high costs.

A number of institutions have used mode 3 extensively instead of (optional) face-to-face tutorials, especially where students are scattered over a wide area. The telephone tutorials provide students with an opportunity to analyse and discuss the teaching materials provided through other media (print, television, audio-cassettes, or the Web).

Mode 4: Tutor to multiple groups

Mode 4 links a tutor in one site to several groups of students at different sites. (This is the same as Mode 2, except a bridge is required). Many universities and colleges in North America and Australia have used mode 4 for direct instruction, with lectures delivered to remote sites, and students calling in with questions to be answered by the lecturer. Either audio-conferencing or video-conferencing may be used.

In this situation, conferencing is likely to be the main form of direct instruction, although students will often be required to read set text books or find library references. Several US state university systems, such as Wisconsin, Nebraska, and consortia of institutions such as the National Universities Telecommunications Consortium have used either audio- or video-conferencing or both for this form of delivery. In such a context, though, the technology tends to be used mainly for lecture-type presentations, with perhaps some 'off-line' local discussion at each site and reporting back.

Mode 5: Self-help groups

One other mode of operation is really a variation on Modes 1 and 3. Students may be encouraged to set up self-help or task-oriented groups. Synchronous web conferencing is particularly useful for students

working collaboratively online on an assignment or task. The activity is often helped if students can set up the task synchronously, then work on it asynchronously, coming back to a synchronous discussion to finalise the task.

Educational applications of tele-conferencing

Robinson (1984, p. 129) found in a study she conducted that telephone tutorials with either individuals or small groups (modes 3 or 4) were effective for the following tasks:

- to clarify student difficulties in course materials;
- to promote student discussion of specific issues and topics;
- to exchange interpretations of or debate a case or thesis;
- to discuss problems of recent written assignments, or strategies for tackling forthcoming ones;
- to discuss, analyse or work through previously-circulated materials (maths problems, graphs, diagrams, illustrations, raw data, etc.);
- to analyse a written text or musical score;
- to present short case-studies;
- to role-play an exercise;
- to practice and evaluate sight singing on a musical course;
- to negotiate the design of a project,

and she found the following were *not* considered effective:

- lecturing;
- constructing a complex diagram from scratch;
- impromptu tutorials or unprepared topics;
- tasks involving a large number of texts or sources;
- groups with constantly changing membership;
- some science, technology and maths topics where dynamic visuals were required;
- conveying lengthy and detailed instructions.

Although this list was developed for audio-conferencing, nearly all of the items would apply to later forms of conferencing, with the exception of teaching subjects where dynamic visuals are needed.

Telephone conferencing can also be very useful for administration, disseminating information to regional staff, for meetings to avoid staff travelling to headquarters, and even for training staff. It is used a great deal for planning and designing courses developed collaboratively by staff at different institutions or campuses. Because of its simplicity and reliability, and multi-point facility, telephone conferencing is often preferable to video-conferencing for this purpose.

Video-conferencing has been used in a wide range of applications to support distance learning as well as conventional instruction. The latter tends to involve bringing in experts or virtual field trips. For example, at the University of Central Queensland in Australia, video-conferencing

has been used to enable campus-based pre-service teachers to watch live teaching at a more remote school without disrupting students in the class. The 'fly on the wall' application combined with talking with the teachers immediately after the class helped bridge theory and practice.

Many U.S. states have deployed large-scale statewide video-conferencing systems. One example is the Georgia Statewide Academic and Medical System, a multi-site videoconference network consisting of 400 locations statewide, with multi-point bridging which connects up to 16 locations at a time. Applications have included student debates, virtual field trips, tele-medicine, tele-rounds, tele-psychiatry, tele-education conferences, and distance learning. Since inception in 1992, GSAMS has successfully conducted over 100,000 videoconferences (Rhodes, 2002). Duran and Sauer (1997) now claim that video-conferencing is at to the point where distance learning has become '...*the* primary application of videoconferencing...' (p. 82).

While video-conferencing to groups tends to focus on visual communication and the transmission of information, web-conferencing systems have placed greater emphasis on collaboration between individuals. Desktop videoconferencing has been used in distance learning as a replacement for larger, more expensive room systems either for direct instruction or to provide learner support. Alberta North, a

consortium of post secondary institutions in Northern Alberta and the Rural Area Training, installed a network of desktop systems into local sites for distance learning meeting applications. The RATIO initiative in South West England uses desktop video-conferencing in learning centres to support video tutoring applications (Wheeler, 1997). Nichol and Watson (2000) found that desktop video-conferencing can be an effective medium for tutoring student teachers at a distance.

Garrison, writing in 1989 about audio-conferencing, claimed that:

> 'Teleconferencing represents a paradigm shift in facilitating and supporting learning at a distance....Of all the means used to support distance education, teleconferencing most closely simulates the transaction between teacher and students in a contiguous or conventional form of education. The exchange is conversational in nature, it may be spontaneous, and it is immediate. In these respects teleconferencing differs from all other technologies used to bridge the distance in distance education.'
>
> Garrison, 1989, p.66

He identified three 'defining characteristics' of teleconferencing:

- a group method of learning;
- regularity and immediacy of two-way communication;

- suited to small and widely dispersed target groups.

For these reasons, Garrison claimed that 'few if any traditional classroom techniques are not adaptable to teleconferencing.'

This shift from individualized to group-based learning enhances opportunities for interaction and collaboration for those who are able to access such technology. Furthermore, video-conferencing technology in particular enables classroom teaching to be extended beyond the instructor's classroom with relatively little adaptation of teaching method. However, the self-instructional model, with audio- or Web-conferencing supplementing print-based study, still plays an important role in distance education. Even when tele-conferencing is the main delivery medium, printed support materials such as lecture notes and directed readings also play an important role in supplementing the tele-conferencing.

The importance of video in conferencing

To what degree is video needed in a networked working environment and what value if any does a‘ talking head’ contribute? Rosen (1996) reported on three studies undertaken by Sun Microsystems, Anderson Worldwide and the University of Michigan that examined the role of video in real time collaborative communications. A summary of the studies is provided below:

- 84 percent of participants indicated that video improved the quality of communication between colleagues and without video, the quality of the discussion was felt to be inferior;
- video was particularly valuable in interpreting pauses in conversation; without video there was some anxiety and confusion;
- the University of Michigan study found that video had a strong effect on the satisfaction of group members and appeared to motivate individuals to work together;
- Sun Microsystems found that without video, collaboration declined among users;
- collaborating with high quality video was perceived to be as good as face to face;
- when video was added to support remote collaboration, the number of e-mail messages dropped; when video was removed, although the collaborative tools were still available, the number of e-mail messages per day doubled.

As the studies suggest, verbal communication may be less effective without video. These outcomes are in contrast to studies that suggest that remote learners can experience anxiety when they appear on camera, resulting in lower learner involvement and participation rates (Armstrong-Stassen, Landstrom and Lumpkin, 1998). There may be

other extenuating factors that come into play to compensate for the lack of video, such as the degree to which people already know one another, the intended learning outcomes, and contextual features. One possible explanation is that web-conferencing uses a desktop computer. This is a more personal and familiar medium of communication compared to the telephone-based video-conference classroom with its accompanying video cameras and large monitors.

Advantages and disadvantages of tele-conferencing for teaching

The main issue that surrounds the value of synchronous technologies is whether, as Garrison stated, distance education should mirror as closely as possible face-to-face classroom teaching, or whether distance education should be based on an educational model fundamentally different from face-to-face classroom teaching. A second issue is the extent to which the various forms of teleconferencing and synchronous communication can overcome some of the limitations of asynchronous technologies, and in particular text and graphics-based Web courses. A third issue is the extent to which the design and use of synchronous technologies influences the effectiveness of the medium.

I will examine some of the arguments put forward in favour of and against synchronous technologies, then return to a final discussion of these three issues.

Collaborative learning

According to Jonassen (1999), learning is more effective when it is undertaken with other learners rather than as a singular, solitary activity. Jonassen (1999) and Oliver and Reeves (1996) have argued that such forms of learning lead to higher quality learning outcomes. Virtual, collaborative, synchronous environments appear to support task-focused, problem-based activities that are highly representative of authentic learning environments and problem-based learning (Jonassen, 1999; Oliver and Reeves, 1996). In distance learning, the two-way video and audio capability of videoconferencing can support increased student interactivity and collaborative work, and can help create social presence among distance learners (Sorensen and Baylen, 2000).

Business practices have been changing within organizations, shifting from individual oriented pursuits to team based practices (Rosen, 1996). The increasing emphasis on teamwork in general demonstrates the need to develop collaborative learning in conventional education as well as distance learning (Cruz, deMoras, Barcia,1998).

Real time Interaction

We do know that interaction between learners and instructors, and interaction between a student and other students, are critical to successful distance learning (Bates, 1995; Moore and Kearsley, 1996). There are many educators who believe that the closer technology comes to simulating face-to-face teaching, the better (UIFS, 1999). For those that believe this, technologies that come closest to supporting or replicating the type of interactions and communications processes that occur in a face-to-face classroom would have an advantage over other forms of delivery. In particular, synchronous systems that are able to provide a high degree of interaction would be particularly valuable.

Some see videoconferencing as one of the most promising technologies to provide interactivity in distance learning (Oliver and Reeves, 1996). Guzley, Avanzino and Bor (2001) claim that the combination of synchronous two-way audio and two-way video has the most promise for maximizing interaction in distance learning. The ability of video-conferencing to support ‘side talk', namely spontaneous discussions at remote sites that occur during presentations, was also noted as being important. Oliver and Reeves (1996) report on the strong attitudinal and motivational gains attributed to this form of social interaction.

In discussing asynchronous, Web-based online learning, Feenberg (1998) writes that the online environment is essentially a space for written interaction. Donath, Karahalios and Viégas (1999, p.2) argue that this is both the strength and the limitation of asynchronous Web-based communication:

> "Most on-line conversation is text. This is partly due to the history of the technology. Textual interfaces were the norm when e-mail, newsgroups and chat-rooms were developed. As a medium for exchanging ideas, text has a number of excellent qualities. It is highly adaptable. With the basic alphanumeric keyboard, people can assemble discourses on any topic. With skill, it can be quite expressive. Yet as a conversational medium, the austerity of text can be detrimental. In particular, it is difficult to convey many kinds of social information, such as conversational tone, patterns of activity - even the size of the conversational group is opaque in most text-based forums.
>
> Asynchronous discussions such as newsgroups or mailing lists are inherently persistent, and recorded logs bring persistence to the [otherwise] ephemeral synchronous text-based chats. Yet the drawbacks of the text-only interface [are evident] when perusing the archives of a discussion. The rhythms of the conversation's exchanges are obliterated and the reader is likely to approach the

> mass of accumulated archival material by searching or non-linear approaches, often losing in the process much of the conversation's context."

Research into desktop video-conferencing suggested it could be successfully used to improve the quality of interaction between students and teachers (Edmonds, 1996). Harmon and MacNeil (1998) found that desktop video-conferencing provided a motivational as well as an informational/reflective role in distance learning for remote learners. Thus it can be argued that synchronous technologies that facilitate real-time, conversational interactive communication have strong advantages over both synchronous and asynchronous forms of text-based communication.

Immediacy

Some have argued that learners prefer having their instructor in close proximity whether this is accomplished virtually or in person (Hardy and Olcott, 1995). Soo and Bonk (1998) have argued that in synchronous learning there is a condensation of information and ideas that cannot easily be duplicated any other way, particularly in online learning environments. Synchronous communication allows for immediate and timely feedback and creates a strong social presence more easily than asynchronous online environments.

Anytime, Anywhere Flexibility

The flexibility of distance learning has been one of its advantages over traditional forms of education. Synchronous technologies, by their very nature, impose more constraints on learners. It is quite common for designers of existing online programs that are largely asynchronously delivered to be resistant to providing live sessions for learners. According to one instructor, "We've made the conscious decision that our audience, who are adult learners, can't meet in a synchronous atmosphere, otherwise they'd be in a classroom" (Jones, 2002 p.1).

However, in a study on learner perceptions of audio teleconferencing, Anderson and Garrison (1995) examined the issue of flexibility. They found that for the majority of the learners surveyed, independence of time and place was not an issue (possibly because these learners had already made a commitment to attend classes at a Learning Centre). Anderson and Garrison point out that:

> 'Many distance educators have refused to incorporate, or have relegated to "optional status", any interactions that restrict student access in terms of time or place. This ideological commitment to independent study denies interactive educational opportunities and choices to students and teachers.'

Anderson and Garrison, 1995 (p. 40)

According to Leasure, Davis, and Thievon (2000) and cited by Ramage, (2002), learners who choose more traditional routes of learning, do so for increased interaction, the perception of better, more meaningful learning opportunities, and pacing. In a survey of barriers to job-related training, Industry Canada found that more than forty per cent of 1.5 million Canadians cited being too busy at work as the main reason preventing them from seeking training. Secondly, they cited a lack of funds or the pricing of courses. Inconvenient time or location came in third.

An asynchronous web based course is ideal for adults who travel frequently, or have erratic schedules. These learners require more flexibility in their learning than an adult learner who can attend a local face-to-face or synchronous tele-conference class. A course based on synchronous tele-conferencing may not have as much flexibility as an asynchronous online course, but it may provide a great deal more flexibility for learners than traditional instruction, if the traditional instruction requires lengthy travel time. Learners may rank real-time interaction via tele-conferencing from a local site as being a particularly useful feature compared with the limitations of asynchronous online communication.

For example, lawyers who attended a continuing professional development workshop that consisted of pre-recorded lectures and live group discussions by web-conferencing reported that the key advantage of this way of learning was its flexibility over traditional face-to-face instruction, which required more time away from the office (Picard and Wood, 2002). According to Gartland, 2002, although there will always be those who need the learning on demand option, there are large numbers of learners who prefer the live interaction of a classroom based setting (either face-to-face or by tele-conference).

Thus we can see that adult learners have varying opinions of what constitutes flexibility within a course. A more fundamental issue is: should absolute flexibility be the overriding consideration in the design and delivery of all distance courses? The research thus far would suggest that distance learners not only benefit from a combination of synchronous and asynchronous technology, but they also prefer this approach.

Improve the quality of teaching

Can we achieve higher learning outcomes with new synchronous technologies? Results are inconclusive. Professors at Michigan State University taught a microeconomics course using live web casting technology (Brown and Liedholm, 2002). The study involved three

cohorts of learners, face to face, hybrid (reduced face to face access but including access to web based tutorials) and off campus (web casting and web based tutorials). The off campus learners attended the same live class as the face to face students, but their view of the instructor and the visuals used in the presentation were viewed through a web browser. Live, two-way interaction made use of text chat. The web cast learners also had access to the recording of the classes, although fewer than fifty percent of learners chose to access this feature. Although the on-site class was large, the instructor made a special effort to involve the learners as much as possible using a lecture, and a question and answer format.

Evaluation results comparing the three groups showed no significant differences on knowledge and comprehension questions. As we have seen this is typical of most if not all carefully controlled media comparison studies. However, the results differed significantly with respect to the higher level skills of applying knowledge, particularly regarding complex applications, because the fully online learners significantly under-performed in comparison to the face-to-face and the hybrid learners.

MacKeogh (1999) argues that although most learners desire independence and freedom in their learning choices, this needs to be balanced with the need for social, collaborative and interactive learning.

MacKeogh argues that independent study works well for certain learning outcomes, but not all.

> 'The development of these higher order thinking skills is best achieved through active engagement with the material through discussion, interaction, and exchange of ideas. Yet it is difficult to achieve this outside a face-to-face situation.'
>
> (Mac Keogh, 1999, p 79)

According to Oliver and Reeves (1996), the majority of interactions found in satellite and audio-graphic settings are social and didactic in nature. Cognitive interactions, which go beyond memory and comprehension to higher levels of thinking are far less prevalent. Their systematic analysis of the types of interactions that occur in virtual, synchronous classrooms (using the social, didactic and cognitive scale which they developed), suggests that most teaching tends to be content-focused, rather than focused on problem solving and critical thinking. More significantly, though, they also found that for a variety of reasons, teachers teach the same in virtual classrooms as they do in their regular classrooms. They question whether the live, interactive capabilities of the media are being used effectively.

Educators have often bolted existing methodologies and practices on to new forms of communication. The lecture method is the most common teaching application and as Oliver and Reeves have shown, such methods are easily transported to synchronous technologies. Thus although the question has been framed as what do synchronous technologies do less well, we might want to ask why is traditional classroom instruction so poor? Why do instructors tend to focus on lower level learning outcomes in their teaching, and why are these methods of classroom teaching carried over to technology-based teaching? Carrying

over conventional forms of classroom teaching to tele-conferencing may in the short term encourage instructors to use tele-conferencing, but in the long term, other approaches to teaching need to be developed that best exploit the teaching potential of these technologies.

Improve critical thinking

A common refrain regarding the benefits of asynchronous computer conferencing is the notion that learners are more reflective, more analytical in their thinking compared to what is seen or heard in a face-to-face environment. The logical conclusion of this argument is that 'live' sessions are best for content delivery, but higher level thinking occurs asynchronously, preferably through asynchronous online text-based discussion forums/computer conferences.

There are several reasons why educators favour asynchronous computer conferencing for more reflective, critical thinking. Because computer conferences can be archived and analyzed later, it is easier to evaluate these discussions than those that occur in the classroom. The limited research that has been done on learner-instructor interactions in the synchronous classroom indicates that the use of memory and content-level questioning is common (Kirby and Boak, 1989; Hardy and Olcott, 1995; Oliver and McLoughlin, 1997). In the asynchronous computer conferencing environment, instructors may be more selective in the types of questions they pose.

This can be illustrated from a graduate level course in Health Sciences taught at the University of Alberta. In addition to four 'live' synchronous sessions using a web conferencing tool, students could also access course materials asynchronously over the web. During the live web sessions, the instructor spent a significant portion of the time lecturing, and the remaining time trying to coax questions and discussion. (At this point the learners were likely engaged in more productive activities such as folding laundry or checking e-mail messages). At the end of each live session, the discussion questions for the computer conferencing were presented. In contrast to the earlier questions, the computer conferencing questions were issues-based, controversial and thought provoking.

Imagine how much livelier the 'live' sessions would have been if the time allotted had been used to discuss the questions posed in the computer conferences. In most web-based courses, the main interaction between learners and instructors is through online discussion forums. Therefore instructors may well put more thought into the types of questions that are posted. Since the computer conferencing environment is less readily dominated by the instructor, learners are also more likely to contribute their own questions.

Time on task may also partly explain enhanced learner responses in asynchronous computer conferencing. In other words performance is a function of the amount of time spent on a task. Reading a large number of replies in a computer conference is time consuming. Ideally, learners read, reflect, formulate and respond to postings. In a synchronous environment, whether face to face or technology mediated, learners responses are usually immediate. Thus responses are given without benefit of lengthy reflection, unless questions have been assigned ahead of time as a way to encourage critical thinking in synchronous settings (an idea endorsed by Hardy and Olcott, 1995).

The issue of quality takes a different spin with respect to the Queens University Executive MBA program, which is delivered primarily by video-conferencing. One faculty member, who has taught videoconferencing courses for several years, has found there is a marked difference between the quality of questions he receives in his distance classes compared to his face-to-face EMBA classes. He attributes the higher quality questions to student conversations that occur while the class is in session. These discussions are both dynamic, and site specific. Because learners are able mute their microphones, they do not disrupt other class members or the instructor. In his view, the small group discussions and the filtering process that the questions undergo before they are presented to the whole group, is one of videoconferencing's key strengths (Wright, 2003).

While small group activity is possible in traditional classroom settings, the real time nature of the dialogue – while the instructor is teaching - would not be possible nor tolerated. In fact it is a cardinal rule that learners keep quiet when the teacher is talking. Thus the technology is able to support a more collaborative model of inquiry that lends itself to better thought out questions, and more complex questions

Certainly, asynchronous computer conferencing is quite different from the temporal, non-linear, spontaneous nature of synchronous environments, and communicating in print is quite different from communicating aurally. Once again, though, the issue is not which is the better, but under what conditions are they best combined

CONCLUSIONS

Synchronous teleconferencing technologies continue to develop and improve. Through a combination of increased bandwidth, faster computer processing, and improved compression technology, synchronous communications technology is becoming more and more accessible for distance learning. Desktop web conferencing is clearly the next step in the evolution of synchronous technologies, offering the promise of full two-way video and audio communication between instructors and students.

One argument for the use of synchronous teleconferencing is that this most closely resembles conventional face-to-face teaching. Although students are not physically present, the students and instructor can communicate, and especially with new Web conferencing technology, students can also communicate with each other, in almost exactly the same way they would if they were physically present in a classroom. (Not everyone would agree with this. According to Schwier (1994): 'Media do not, and probably will not, successfully duplicate the power, flexibility, and immediacy of face-to-face instruction' (p.215)).

The trouble with the argument that synchronous technologies best replicate classroom teaching is that it assumes that conventional classroom teaching is the best way to teach and cannot be improved. The argument denies the possibility that technology may allow for different and possibly better ways to teach. Certainly, there appear to be strong benefits in addition to increased convenience and flexibility for learners (and instructors) from an asynchronous approach to learning, such as more time for reflection, more time on task, and more opportunity for knowledge construction.

The second argument is that although there are benefits from asynchronous approaches to learning, it also has its disadvantages, and synchronous technologies can help overcome these. This is a more

convincing argument. Synchronous communication offers immediacy and the opportunity for both instructor and students to interpret body language, tone of voice and other more subtle non-textual features of communication. Synchronous communication allows for the more affective side of learning, such as creating vibrant and dynamic discussions, and increasing social presence.

However, these advantages tend to be lost if synchronous communication is largely used for information transmission or lecturing, and yet this is the danger if instructors are not trained to understand the strengths and limitations of the medium. In many of the examples quoted, poor results were obtained because of inappropriate use of the technology, rather than due to any inherent weakness in the technology itself. Many distance learners will often prefer the advantages of synchronous communication, even if it means a trip to a local centre. Nevertheless, having said that, for many distance learners, synchronous video-conferencing is either inconvenient or not a very effective medium of communication. Web- conferencing may overcome some of the inconvenience, but at the time of writing, we are just beginning to get experience in this form of teaching, which is still restricted to audio, graphic and textual communication.

In summary, technology has evolved to the point where individuals can engage in discourse, both synchronously and asynchronously using a wide range of tools. However, in most circumstance a combination of synchronous and asynchronous communication will offer the best learning environment. For example, at Northern Arizona University, asynchronous computer conferencing was added to a fourteen-site, 150 student video-conference course. Despite the large numbers, there appeared to be little difficulty in encouraging asynchronous computer conferencing use because learners were able to see one another periodically. According to Motteram (2001) learners feel more secure in sharing ideas when they have seen one another visually. Points raised in classes were discussed in greater detail asynchronously; and the authors noted that the combination of technologies provided substantial learner to learner interaction that had not been possible before (Collins and Zane, 1998).

Although it is clear that video-conferencing provides greater teaching advantages over 'audio-only' conferencing, more studies are needed comparing synchronous with asynchronous learning - or rather, more studies are needed that look at the circumstances where synchronous and asynchronous technologies are best combined.

Common sense suggests that real time video, audio, graphic and textual communication will be the best combination of synchronous approaches, where this is technologically and economically possible. However, the discussion of research into the benefits and limitations of various types of synchronous communication indicates that there are no overwhelming educational arguments for one particular type of conferencing over another, or even for synchronous over asynchronous forms of distance education. In particular there are no clear instructional guidelines as to what is best done synchronously and what asynchronously. Until we understand better these differences, the benefits of a particular synchronous technology are likely to be driven by other considerations, such as access, cost and organizational context. Thus it is important to look at the costs and organizational issues around the use of synchronous technologies, which is the subject of the next chapter.