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## A LEARNER ORIENTED INFRASTRUCTURE FOR VIDEOCONFERENCING BASED DISTANCE EDUCATION COURSES

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### ABSTRACT

Over the last few years distance education has assumed increasing importance and is returning from its languishment over the last few decades. This has primarily been due to the availability of facilitating technology like video-conferencing, the internet etc. However, there haven't been many studies examining the utilization of the latest technologies to create an effective distance learning 'classroom'. This paper studies two such emerging technologies - the Interactive Video Network (IVN) technology and the Internet. This paper discusses how the IVN and Internet can be used to enhance student learning in a distance education environment. It creates an infrastructure for integrating these two technologies into mainstream courses that are currently taught in universities. The paper discusses one such experiment and reviews the experience gained.

### INTRODUCTION

Higher education has witnessed a tremendous growth in the area of distance education since the late 1980's. Distance education is now being perceived as an integral part of higher education. This change is due to the availability of compressed video, innovations in the area of computer based education and the world wide web.

Still, there is a reluctance on the part of educators to embrace distance education partly due to the limitations in the level of communication between the instructor and the learners. Also, many logistical constraints make distance education unappealing to educators.

This paper addresses some of these issues by creating an infrastructure that combines different information technologies. This infrastructure will help solve some of the current limitations of distance education and make it more acceptable to educators. A distance education course was taught using this infrastructure. Experiences and results from evaluation of the course are presented.

### DISTANCE EDUCATION

Holmberg (1995) defines distance education as teaching & learning situations in which teachers and learners are geographically separated, and therefore, rely on electronic devices and print materials for instructional delivery. Most definitions of distance education emphasize that the interaction between the instructor and the learner is conducted using one or more media though this media need not necessarily be electronic (American Council on Education). The instructor and at least some of the learners are situated in remote locations. The different media enable either synchronous or asynchronous interaction between the instructor and the remotely located learners.

### Modes of Delivery of Distance Education

Distance education courses have been offered by institutions of higher education since the turn of the century. The modes of delivery have changed dramatically over the past few decades due to the availability of technology enhanced media. The modes of delivery are discussed in two groups, non-technology based modes and technology based modes.

Non-technology based modes: These modes required little or no use of technology. The instructor and learner had very limited interaction.

Correspondence: The oldest mode of distance education delivery was correspondence. Learners were mailed instruction material, exams and projects. The learners taught themselves, took the exams, completed the projects and mailed them back to the instructor for grading.

Correspondence & Meeting: Improvements in the transportation and communication infrastructure enabled learners and instructors to have a limited number of meetings in addition to correspondence. Most of the learning takes place via correspondence. This mode is still used by institutions for executive training and continuing education.

Technology based modes: The improvements in the telecommunications infrastructure, innovations in audio and video technology, and the advent of the Internet has reshaped distance education in a dramatic fashion. Most of the technology-based modes improve the interaction between the learner and the instructor. Technology based modes may be synchronous (where the delivery is real time, akin to using a telephone) or asynchronous (where the delivery is not real time, akin to watching a videotaped lecture). It can provide for either one-way communication only (for example, students can hear or see the instructor but cannot

communicate back) or two-way communication (students can hear/sec the instructor and in turn can be heard/seen by the instructor). Technology based modes include:

Audioconferencing: Audioconferencing could be either one-way or two-way. The learners can hear the instructor and the instructor may be able to get audio feedback from the learners if the communication is two-way.

Audiographics: In addition to transmitting his/her voice, the instructor has the ability to send still images and graphics. In the simplest implementation, the instructor uses a facsimile machine to transmit the images to the remote site.

Computer Mediated Education (CME): Computer mediated education could be either synchronous or asynchronous. An example of an asynchronous implementation would be using electronic mail or a listserver to teach the course. An example of a synchronous implementation would be using a virtual chat-room to teach the course. The learners and the instructors sign-on to a specified chatroom at a given time and interact with one another on real-time. Variations include use of microphones, sound cards and audio chat software like First Class or the use of desktop video cameras and software like CU-Seeme, FreeTel, CoolTalk etc. (which allows the participants to see video images of one another). With the advent of the world wide web, computer mediated education has become extremely popular.

Videoconferencing: The learners can see video images of the instructor. In some cases, the video images of the learners are also transmitted back to the instructor (if both the sites have compatible equipment). In other cases, the learners use telephone (or other audio equipment) to interact with the instructor. A variation of the videoconferencing mode is Interactive Video Networks (IVN).

Interactive Video Networks: IVN is a multimedia videoconferencing system. Video images are compressed and transmitted over a digital communication line. The compressed images are decompressed and displayed at the receiving site. The compression and decompression are performed by a computer. The transmission and receiving of images is real-time (30 frames per second over a Ti line) but receivers can experience some delay due to the compression/decompression. IVN supports video, audio, still images, and computer generated images (screen). The sending and remote locations normally have similar equipment. The equipment consists of a computer, one or two video cameras, two to four video monitors, a projection camera (for still images, slides and props), microphones, and a tablet to control all these devices. The instructor can control the cameras in one or more remote locations and see images of the learners. The infrastructure suggested in this paper assumes that the course will be taught using IVN or similar two-way videoconferencing facilities.

## Learning Theories

Education in the U.S.A. is undergoing a major paradigm shift. Educators are moving away from the traditional teaching-oriented objectivist theories to the more learner-oriented constructivist and experiential learning theories. The infrastructure suggested in this paper subscribes to the learner oriented theories. Some of the learning theories are briefly described below.

*Objectivist Theory of Learning:* Also known as the stimulant-response theory, it is mainly behavioral in nature. This theory was originally suggested by B.F. Skinner (Skinner, 1953). Learning is defined as a change in behavior in response to a stimuli that occurs in the environment. This assumes that there exists an objective reality (Jonassen, 1993). The instructor is the source of the knowledge about this objective reality. The goal of teaching is to facilitate the transfer of this knowledge from the instructor to the learner (Leidner & Jarvenpaa, 1995). In terms of instruction, the lecture method is predominantly used (McKeachie, 1990). The instructor is responsible for the transfer of knowledge and he/she controls the content and the pace of the course. The learner plays a very passive role in the whole process.

*Constructivist Theory of Learning:* This is considered by many as a meta-theory as it encompasses many cognitive and other theories of learning. The constructivist theory was first suggested by Bruner (1966) and is based on the Piaget's research on child development. Learning is considered to be an active process in which learners construct new ideas or concepts based upon their current/past knowledge (Bruner, 1966). Each learner constructs his/her own knowledge (Yarusso, 1992). It is a learner-centered theory in the sense that individuals are assumed to learn better when they are forced discover the reality themselves rather being instructed on what reality is (Leidner & Jarvenpaa, 1995). The instructor plays the role of the mediator by providing constructive examples. The learner uses his/her own experiences, past knowledge, imagination, and investigative abilities to create abstract knowledge out of the examples. Offsprings of the constructivist theory include the cooperative (collaborative) theory and the experiential learning theory.

*Cooperative Learning Theory:* Cooperative theory assumes that learning emerges when individuals interact with other individuals (Slavin, 1990). The

learner not only interacts with objects, he/she also interacts with other learners. Discussion and sharing of information form the basis for learning. The different understandings contributes to a new, shared knowledge (Whipple, 1987). Communication in collaborative settings must allow branching and concentricity as compared to a linear instructor controlled communication (Flynn, 1992). Numerous studies have demonstrated the superiority of collaborative learning over other modes. Johnson and Johnson (1989) provides a complete review of these studies. A recent study of collaborative telelearning using desktop video equipment done by Alavi and others, showed positive results (Alavi et. al., 1995). Flynn (1992), and Schlecter (1990), also conducted studies that demonstrated the superiority of cooperative learning over individualized learning approaches. Assumptions made by the cooperative learning theory include: knowledge is created as it is shared and more is learned as more is shared, learners need to have prior knowledge in order to contribute, participation is critical, and learners will participate given optimal conditions such as small groups to work with (Leidner & Jarvenpaa, 1995).

*Experiential Learning Theory:* This theory is related to the constructivist theory in the sense that it is learner oriented. It is also closely linked to the cooperative learning theory. Experiential learning was suggested by C. Rogers (1969). Experiential is learner initiated and requires personal involvement on the part of the learner (Rogers, 1969). All human beings have a natural propensity to learn. The role of the teacher is to facilitate such learning (Rogers & Frieberg, 1994, Coombs, 1982). The experiential learning theory assumes that the learner has the knowledge and experience to initiate and direct the learning process. It is also assumed that collaboration among learners might enhance this learning process.

## Justification For A Learner Oriented Infrastructure

The limitations of IVN (discussed below) and the strong subscription to the constructivist learning theories (mainly the collaborative and experiential learning theories) motivated the authors to develop this infrastructure. Past research shows that a combination of collaborative teaching and technology often produced positive results in student achievement (Means, 1993). Moreover a teacher-oriented approach may not be appropriate for a major portion of the audience consisting of adult learners who have work experience and good investigative and analysis skills. Student driven learning and provision of opportunities for interaction with peers and instructors have often resulted in success for learners in distant classrooms (Barker, 1992. Beare, 1989, Jost, 1990, McNeil, 1991, Milne, 1990).

The infrastructure needs to be learner oriented in the sense:
- It should allow for maximum participation on the part of the learner in the learning process by providing multiple channels of communication between the instructor and the learner and among the learners. Isolation from learners in remote sites require the development of direct communication facilities among peers (Paulet, 1988)..
- Learning as a group should be encouraged by providing support for communications, and sharing of knowledge among group members.
- Provide access to various sources of knowledge and real world learning experiences
- Incorporate flexibility in the course so that it can be taught at a pace that the learner desires.

A distance education course using IVN as the sole mode of delivery has the following limitations:
- *Lack of proper communication facilities for interaction:* The communication between the instructor and the learners and also the among the learners is restricted to the class lecture times in an IVN setting. This is especially true between the instructor and the students in the remote locations. This limits the extent to which students can interact as a group (essential for group projects) and maximize learning.
- *Logistical Problems:* Instructors planning to teach an IVN course have to plan well in advance to convey course materials (course outlines, syllabi, homeworks, projects, and exams ) to learners at the instructor's and remote locations. Another problem is collecting the homeworks, projects, and exams from the students at remote sites, grading them, and providing feedback within a reasonable period of time (same tune as learners in the instructor's location).
- *Lack of flexibility in the course:* Since most of the interaction between the instruction and learner is restricted to the classroom, the instructor is restricted in his/her ability to make changes to the course to accommodate the requirements of the learner. Collaborative and experiential learning requires that the course be taught at the pace of the learner. The course tends to be instructor driven and linear in fashion. It also does not allow for branching and concentric forms of learning which are essential for adult learners.
- *Isolated Classrooms:* According to a study published by the National Education Association, the education system in America portrays the classroom as an island on which the teacher, a group of students, standardized textbooks, and other limited resources exist in isolation. This is also true with distance education classrooms using videoconferencing. Learners need multiple sources of knowledge that they can assimilate as a part of the learning process.

*Other problems:* Due to limitations in the technology (slight delays in receipt of signals), and restricted class times learners, especially at the remote location, tend to be passive listeners rather than active participants. Sometimes the technology fails and there are no backups or alternative ways of delivering the lecture to the remote site.

Almost all of the problems stated above can be overcome by providing alternative modes of communication. Such an augmentation of the existing video conferencing facilities would add more flexibility to the course, solve the logistical problems, and improve communication among the learners and between the learner and the instructor. An alternative channel of communication which can enhance teacher-student and student-student interaction is the Internet.

### Internet Resources

The Internet is a network of networks that connects thousands of computers that are located all over the world. These computers share a common protocol (TCP/IP) that allows them to share data and communicate. Many resources are available as a part of the Internet that will help overcome the limitations of the videoconferencing facilities. The characteristics of these resources and how they can be used as a part of the infrastructure to offer an effective distance education course is discussed below.

*Electronic Mail:* Electronic mail (email) is an asynchronous resource that is available on the Internet. Email allows learners to communicate among themselves and also with the instructor outside the classroom. Group discussions can be carried using email. Newer MIME based email packages allows users to transmit wordprocessed documents, spreadsheets, and even pictures. It is an excellent medium for continuing the dialog outside the classroom.

*Usenet:* The usenet is a set of electronic bulletin boards (or newsgroups) on the Internet. Each newsgroup has a subjects and thousands of newsgroups exist on the Internet. Users can view the messages posted to a newsgroup and also post messages to the newsgroup. Usenet is asynchronous communication medium.

*Internet Relay Chats (IRC) and Talk Utilities:* IRC, also referred to as chat rooms, allows users to talk to one another in virtual rooms. The communication is synchronous. Newer software like CoolTalk allow users to communicate using microphones and virtual whiteboards on the Internet. Some users have invested in desktop video cameras and communicate over the Internet using both audio and video signals.

*Hypermedia and the World Wide Web (WWW):* Hypertext based software allows instructors to provide links between documents that have a common theme.

A user of a hypertext-based document can click on specially marked phrases in a document and link to other documents. Hypermedia has taken hypertext to another dimension. A hypermedia-based document can link to other documents which may sounds, pictures, and even full motion video contain in addition to text. Such software allows the instructor to use multiple media while teaching in the classroom. Hypermedia based software like Netscape are available at a nominal price (or free of charge) to academics. Learners can use hypermedia-based documents to learn at their own pace. Hypermedia also supports branching and concentricity. Learners need not browse the documents in a linear fashion. They can click on different links and branch to other topics.

The World Wide Web (also known as WWW or the web) consists of millions of hypermedia based documents called pages. The web is a source of rich and valuable information on almost any topic. Web based documents can be accessed from any computer with web browser software. Many disciplines have created information junctions (for example, IS WORLD for information systems related courses) that provide links to web resources related to that discipline.

*Other Internet Based Resources:* Internet based resources like Gopher, Listservers, File Transfer Protocol sites, and Telnet and search facilities like Archie, Veronica, and Jughead are very useful in providing multiple sources of knowledge for the learner. For a good description of these resources refer to Ed Krol's book, The Whole Internet (Krol, 1995).

### Description of the Infrastructure

The infrastructure that is proposed in this paper combines videoconferencing with some of the resources that are available on the Internet to create an environment that enhances the collaborative style of learning. The components of this infrastructure are:

- Videoconferencing Facilities: Host and remote classrooms have two-way synchronous videoconferencing facilities. These facilities allow the instructor and the learners to interact with one another during the class times. A facility similar to the Interactive Video Network described earlier would be suitable for this purpose.
- Modes for interaction, communication and sharing of information:
  *Group projects:* Learners from various locations must be placed in-groups to do group projects. This will force learners who are otherwise not in physical proximity to interact with one another and learn collaboratively.
  *Electronic Mail (email):* Instructors and learners have access to email. Email is used for communication outside the classroom. The email software should be easy to use and

MIME compliant so that it supports binary attachments in addition to text files.

- *Usenet:* The instructor should create a newsgroup for the class. This will allow the learners to post messages and communicate with one another. This will provide an alternate source for group interaction outside the classroom. Dillon et al. (1992) suggest the setting up of computer bulletin boards for individual classes.

- *Talk and Chat facilities:* Talk and chat facilities support two-way synchronous communication among the learners. The instructor can also be available in a chat room to talk to the learners at specified times and can thus hold 'electronic office-hours'. This will increase the interaction outside the classroom.

- *Learner web pages:* Learners should be encouraged to create a web page providing information about themselves, their work experiences, and areas of interest. This would allow learners located ax various remote sites to get to know one another and form groups.. The learner pages will be linked from the course web page. This will allow learners to know and facilitate communication with remote site students.

• Logistical issues

- *Web based course syllabi, notes, handouts etc.:* The course description, syllabi, and all the class notes will be available at the course web site. Learners can access it from anywhere. This will solve the logistical problem of conveying the course material to the learner. The instructor will also have the flexibility of modifying the course to suit the pace of the learners since only one copy of the course material has to be updated. The instructor should send email to the learners to access the course web site when such modifications are made.

- *On-line homeworks and exams:* All homeworks and project outlines will be available at the course web site. When a learner finishes an assignment, he/she can send it to the instructor as an attachment to an email message. This solves a major logistical problem of conveying and collecting assignments. Exams can be on-line too. Forms can be used on the web to create on-line exams, and with the appropriate CGI programs the learner's answers can be electronically transmitted to the instructor. With newer languages like Java™, the learner can get instant feedback on which answers were right or wrong (in case of a multiple-choice format).

• Multiple sources of information:

- *Links to information on the web:* On-line class notes should also provide links to information junctions on the web. Learners can browse these junctions for information in addition to what is conveyed in the classroom and what is available in the class notes. Learners should also be encouraged to search the web using search engines for other sources of information. Availability of multiple sources of permits one to move away from the linear flow of information and allows the brancing and non-linearity advocated by the collaborative learning theory.

- *Access to other resources on the web:* Learners should have access to Gopher, Listservers, etc. and should be encouraged to use these resources to gather more knowledge.

• Training for instructors and learners: Instructors should be trained to use videoconferencing equipment. They should also be proficient at creating web pages and using Internet based resources. Learners should receive limited training in using the videoconferencing equipment (in case of an emergency). They should also be taught to access and use Internet based resources during the first class.

The infrastructure described above can be adapted to any videoconferencing based distance education course. The authors used this infrastructure to teach a course about the Internet. A description of the course and the outcomes of the course are discussed below.

**Description of Course Taught Using the Infrastructure**

The authors, using the infrastructure outlined above, created and taught a course about resources on the Internet. The course was taught at two sites using IVN facilities. In a traditional IVN format classroom one site is the broadcast site (the site where the instructor is located) and the other site a remote site. There are students at both sites. For the class taught by the authors, each site got equal time in terms of being a broadcast site and a remote site since there were two instructors. This had the additional advantage that each student regardless of the physical location had the unique experience of being a broadcast site student as well as a remote site student. They were, thereby, in a position to evaluate the pros and cons of each experience. The course syllabi, requirements, handouts, and lecture notes were made available on a web site. Handouts for homeworks and projects were also posted on the web site. Students returned completed homeworks to the instructors via email. The exam was also posted on-line on a web site using forms. Questions in the exam were of both the objective and the subjective variety. Students submitted the completed exams to the instructors electronically. All students had email accounts, which they used to communicate with the instructor and among themselves. The instructors also created a usenet group for the course where the students posted messages. Initially, the instructors created a web page with the

students' pictures and email addresses. Students used this web page to form groups for collaborative projects. The groups were required to have members from both campuses. Eventually the course page provided a link to each student's home page. Students were also taught how to use the IVN equipment. They used IVN to make group presentations from both sites.

**Evaluation of the Course**
The evaluation of the course was done using a questionnaire. The questionnaire used was based on a form that was developed by the University of Maryland System (UMS) distance learning initiative. The original UMS questionnaire was augmented with questions to evaluate the internet component of the course. The questionnaire is available with the authors if anyone is interested in seeing it. Student feedback was solicited with regard to (a) the physical/technical logistics of the IVN technology, (b) evaluation of the class experience (c) Outcomes and (d) the Internet. Each category comprised questions, which was rated on a likert scale ranging from 1 to 5, 1 being the least positive and 5 being the most positive. The categories for some questions ranged from poor to excellent, and in others from strongly agree to strongly disagree. Some of the questions were open-ended. Since this questionnaire was administered online, it was not possible to get a 100 % response rate, as it was not possible to monitor who had filled out the questionnaire and who had not.

| Sr. No. | Category | Average Score |
|---------|----------|---------------|
| I | Technical/Physical Logistics | 4.06 |
| II | Evaluation of the Course | 4.14 |
| III | IVN Outcomes | 3.89 |
| IV | Internet | 4.50 |

The table above presents the detailed quantitative results of the survey. Questions, which were open, ended and subjective in nature included
a) drawbacks and benefits of the IVN technology
b) Most helpful Internet resources for communicating with Instructor
c) Basic Internet tools needed to make this infrastructure beneficial

As can be seen from the table, the students felt that overall, the course succeeded in meeting its objectives. The average score of 4.06 on the technical and physical logistics suggests that the students were fairly pleased with the IVN technology. The score in this category wasn't too high as there were some problems due to the audio link between the two sites failing at times. A score of 4.14 on the overall

evaluation of the class experience indicates that the class experience was enjoyable barring some drawbacks. Limited interaction with the remote site students was listed as cited as one of the problems. This suggests that the IVN technology may not adequately parallel a traditional in-class experience. The high score of 4.5 for the Internet-related component of the score suggests that augmenting the IVN with Internet resources did enhance the availability of material as well as the communication with instructor at the broadcast as well as the remote sites.

Some of the advantages of IVN technology were stated as providing access to a class that may not be available at their site. In addition, even for a specific class, one can have access to the combined real-time knowledge of multiple experts from different sites. The exposure to the new technology was felt to be a merit. Apart from some audio and initial adjustment to the technology students found *it* to be an enriching experience. Amongst the Internet resources available, students found email and the world-wide web (with its links and search capabilities) to be the most useful tools which should be part of such an infrastructure.

**Conclusions**

This study attempted a first cut at the creation of a framework for future distance education courses using the emerging technologies of videoconferencing and the internet. The infrastructure was created using the learning theories as the fundamental basis for developing an effective distance education classroom.
The classroom experience yielded valuable insights into how one can effectively combine the IVN technology and Internet resources. Admittedly, this was only an initial foray and further data needs to be gathered on how one can fine-tune the infrastructure.
This infrastructure was applied to a solitary course. Further experiments need to be done with a broader variety of courses to glean more information as to which components are essential and integral to a successful distance learning class. The initial results thus suggest that it is possible to simulate a traditional classroom using the latest technology and the barriers are not insurmountable. However, it is clear from the foregoing discussion that some basic elements like multiple modes of communication (synchronous and asynchronous), multiple sources of information (in and out of class) and alternate modes of information access (linear as well as non-linear) are essential ingredients of the framework.

References available upon request from first author