INTERACTIVE MULTI-MEDIA DISTANCE LEARNING: AN INSTRUCTIONAL DESIGN CHALLENGE

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ABSTRACT

Currently, Air Force technical training courses are taught traditionally, i.e., in a classroom with instructor lecture as the primary method of instruction. This requires students to travel where classes are being offered, often for extended periods of time. When distance learning is introduced, there is rarely a departure from the traditional instructional lecture paradigm. This paper reports the development of a distance learning system and instructional design approach that changes these practices for improved learning.

INTRODUCTION

Armstrong Laboratory developed a synchronous two-way audio/two-way video system called Interactive Multimedia Distance Learning (IMDL). The IMDL system allows linkage of PCs at remote sites over phone lines eliminating use of costly satellite up- and down-links. The bandwidth available on T1 phone lines allows for a high-enough level of visual image transmission to permit *hands-on* performance to be taught at a distance; something that current Air Force satellite distance learning networks are incapable of doing.

Hardware and software are not the only distinguishing characteristics of the IMDL system. In addition, a new approach to instructional design was developed. Instead of focusing all attention on the instructor as in many satellite systems, the IMDL system incorporates interactive multimedia scenarios, collaborative student exercises, dynamic instructor diagnostic tools, and instructor-led question and answer sessions or discussions. The resulting instruction advocates learners to be independent in setting their goals. It encourages collaboration among students in studying course information and applying it in new ways to problems they are faced with in classroom scenarios. Instructors are not left entirely out of the picture. Because of the built-in diagnostic tools available to them, instructors can immediately identify concepts that students are not learning or having problems with and tailor their instructional approach and content to the specific needs of the class or individual students. By viewing a histogram of student responses to embedded questions, instructors can identify points of disagreement, moderate class discussion of the concepts and ensure that the class has reached closure on the topic. This open approach to learning has already been tested by a commercial organization, the National Center for Manufacturing Sciences (NCMS)[1]. The combination of the IMDL suite with the open approach to learning will be tested by the Air Force to deliver their basic academic counseling course at a distance in June 1997.

IMDL CONFIGURATION

The IMDL system consists of a variety of specialized hardware and software that creates a two-way audio, video, and data environment (the virtual classroom) in which students and instructor can interact. Hardware for the IMDL system really comprises two separate collaborative systems: an NTSC video teleconferencing system and a digital data conferencing system. These systems are interconnected because they share a single *T1* telephone line for communications. Three critical elements of the IMDL system are:

[1] NCMS is an alliance of government and major manufacturers in a wide range of industries from automotive and optical to semiconductor.

1. the instructor suite
2. the classroom or student site, and
3. the communications bridge.

Instructor Suite. The testbed instructor configuration is comprised of a standard PC with customized software that enables the instructor to perform various virtual classroom instructional functions, video cameras to transmit the instructor's virtual presence, an *Elmo* for close examination of objects, and an AMX control panel which enables the instructor to control instructional events in the virtual classroom. These components are depicted in Figure 1.

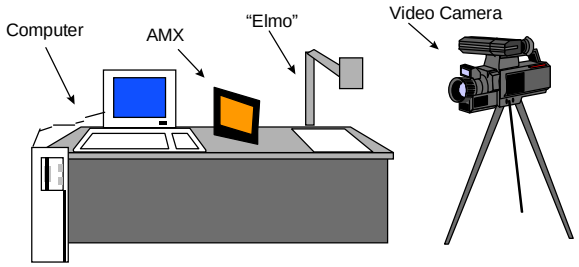

Figure 1. Instructor Suite

Student Site (Classroom). The virtual classroom consists of a PC for each student networked together, an individual *Flexcam* at each station, a classroom server controlled by the instructor, an *Elmo* for demonstrating to the instructor and the rest of the virtual class, a printer, and a hub connecting the virtual classroom to the instructor and the Internet. Student sites can come in classroom configurations as the one depicted in Figure 2, or individual sites which can be linked together to form a single virtual classroom. While, in theory, there is the possibility to configure a large number of students into a virtual class[2], in reality, we feel there is a practical limit as to how many an instructor can handle at any time. This is more likely to be in the range of less than thirty.

Communications. Communications between the instructor and the virtual classroom takes place over T1 lines. There are two types of signals that pass over the communications bridge: analog NTSC video and digital data. The NTSC video teleconferencing system is based on the Intel *Indeo* 3.2 standard. In general, usable quality ranges from data rates of 364 Kbps to 768 Kbps. The IMDL system uses data rates of 768 Kbps, although other rates may work effectively as well. Because video and digital data conferencing share a single T1 line, increasing video quality reduces data network bandwidth (and speed), so we will want to find the best balance for optimum performance.

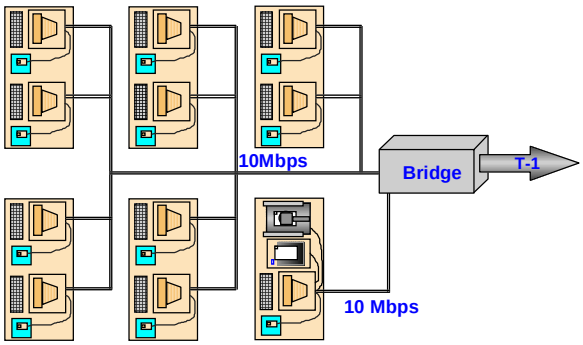

Figure 2. Student Classroom

INSTRUCTIONAL DESIGN

The system developers know that the IMDL hardware and software alone can not achieve a significant increase in learning. An instructional design approach that takes full advantage of the system's capabilities is also needed. To understand why the instructional design approach described is being used, let us first briefly examine the capabilities of the IMDL hardware and software suite.

IMDL Capabilities

A Delphi panel convened by Armstrong Laboratory reported that an IMDL system should have the following capabilities: application sharing, messaging, an annotation tool, an evaluation tool, a grouping tool, and productivity tools. Therefore, the IMDL system was designed to be capable of the following:

- Show instructor on each student station screen simultaneous with another application, e.g., PowerPoint, video, etc.
- Typical presentation software should run *in-sync* on all student stations.
- Student stations can be grouped together into independent self-directed clusters.

[2] The number of student connections is strictly determined by the size and number of hubs in the system. Currently, we are using a single hub of 25. Additional hubs (up to five) can be daisy-chained together. Hubs of 50 are also available.

Clusters can be configured so that one station (instructor or student) acts as the group leader. Clusters have the same capability as the entire virtual classroom configuration, i.e., application sharing, annotation, learning tools, messaging, etc. The instructor can join or monitor any cluster. Clustering is implemented by Microsoft *NetMeeting* with modifications.

- The instructor can present questions to the students and immediately see the class results. Students answer questions on-line and a histogram of the results is built in real-time at the instructor station.
- Anyone (instructor or students) can annotate a document on screen. Annotation allows the instructor to add information or comments to material being presented on screen to clarify, explain or expand on a concept. In IMDL annotation is implemented by Microsoft *NetMeeting* with modifications.
- Students can *raise their hand* electronically. The instructor can respond to a particular student, to the group, or clear the had-raise cue and continue with the class.
- Students can send e-mail to the instructor to ask questions or provide homework input. The instructor can pass assignments to the entire virtual class or to clusters or individuals. E-mail will probably be used most frequently in larger classes where the instructor's span of control is limited.

INSTRUCTIONAL DESIGN

Basis for Design

A drastic fall-off in audience participation from the beginning of one course to its end prompted concerns about interactivity by the National Center for Manufacturing Sciences (NCMS) for its distance learning program (Reesman, 1996). Initially, questions were eliciting approximately 80 responses each, but over the three hour broadcast there was a 65% reduction in responses to questions, i.e., from a high of 85 responses to a low of 30 responses. This drop-off indicated waning interest in the course as it progressed. The primary cause of decreased student participation was that the course was presented as a typical classroom lecture with little or no meaningful interaction (Walsh, DeVega-White and Finley, 1996).

Subsequently, two interactive distance learning (IDL) courses were developed and offered by the NCMS. One course included nine instructional design techniques based on constructivist educational principles. These specific instructional design techniques were successfully applied to one of the courses. Evaluation data from both courses (Walsh, DeVega-White and Finley, 1996) showed that the design improved student performance such that:

- Students felt more comfortable asking and answering questions.
- Students thought the learning activities better supported course objectives.
- They felt the pace of the course was better.
- The instructor's explanation of course content was perceived as clearer.
- Students felt the instructor interacted with participants more effectively.

Montague and Knirk, (1993) provide a wealth of practical principles of what works in adult instruction. Several of these were used to formulate the IMDL instructional design approach. The major points considered are:

1. *Organizing students into small groups to study improves their performance*. The IMDL system allows students first, to be grouped into a virtual class, then into small clusters.
2. *The closer instruction is to actual technical performance the greater its effectiveness*. Two-way video provides the instructor the opportunity to witness actual student performance of skills learned. The IMDL computers permit simulation of the technical environment and tasks.
3. *Student perception of who controls the key events in learning significantly affects achievement*. Students actually control their learning while in clusters. The instructor can turn over control of the virtual classroom screens to individual students to demonstrate their concepts and ideas.
4. *Providing representative examples and contrasting them with bad examples promotes skill learning*. Simulcast video enables students to view numerous examples of skill performance both correct performance and typical errors to avoid.
5. *Learning is an active process for students*. Students are asked to set their goals at the

course outset. Students collaborate to create a performance checklist and use it to evaluate each other in the course.

6. *Instructors must motivate students to take an active role in learning*. IMDL tools enable instructors to relinquish control yet still maintain a grasp of what students are doing and how well they understand concepts.
7. *Frequent, systematic evaluation informs students and instructors about learning progress*. The IMDL questioning capability provides instructors immediate evidence of whether instructional activities are effective. Questions which can be answered in more than one way provide students opportunities to formulate their ideas and express them to the entire class.
8. *Constructive feedback increases motivation and learning*. With the IMDL questioning capability instructors can tailor feedback to the class, clusters or individuals. Student performance receives immediate feedback from peers and instructor by means of an on-line evaluation checklist.
9. *Systematically organized instructional materials are more effective than conventional classroom instruction*. The IMDL tools help instructors organize what they are going to teach. The course curriculum is entered into an event-driven script that prompts the instructor's next set of actions and teaching activities.
10. *Simulation and games provide excellent substitutes for actual performance*. IMDL computers provide simulcast video to depict simulated environments, multimedia capabilities to execute simulated activities and *white-boarding* so that the instructor can annotate student performance on-screen.

Interactivity

A major contributor to instructional effectiveness is interaction. Why is interactivity important in learning? Knowledge acquisition is a deeper cognitive process of building connections between existing knowledge structures and new phenomena. Parrish (1995) points out that lectures and textbooks are efficient means of disseminating information to large groups of people, but without accompanying interactivity these are largely ineffective methods of developing knowledge that students can transfer to real world activities.

Moore (1989) defines three types of interaction in distance education, that between the instructor and students, between students and the materials and between students and each other. Some distance learning researchers (Burnham, 1994; Hillman, Willis and Gunawardena, 1994) would expand this to include interaction with the technology/interface as another type of interaction. For instructional design purposes, we define interaction as mental and/or physical participation by the students in the learning process.

Main and Riise (1995) developed a taxonomy of interaction. In it they list six categories of interaction as a starting point for distance learning design and research: amount, type, timeliness, method, spontaneity and quality. These categories provide the instructional design team with tangible ways of ensuring enough interaction is included in IMDL courses.

Murphy (1996) indicates that instructors talk for approximately 86% of the time during a class.[3] One might assume that students get to talk the other 14%, but their participation really only occupies 9.6% of the time with the balance consisting of silence! Of the brief period of time devoted to student talk, they discuss administrative details or system related problems 3.4% of the time, leaving only 6.2% of class time for students to focus on *cognitive* talk, i.e., discussion of what is to be learned.

It is obvious to us that for interactivity to really work in IMDL courses, instructors must plan for and be willing to relinquish control to students some of the time. Giving up control can be a threatening predicament for an instructor. Throughout their entire professional lives, instructors have been raised in and imbued with the *cult of control*. Assuming that everyone *wants* to increase interactivity, and that there are certain issues such as control that need to be grappled with, what should be the focus in order to create meaningful interaction?

While spontaneous interaction tends to make students feel better about the course, the interaction doesn't really have to be spontaneous - only appear so to the student. Fulford and Zhang (1993) found the perception

[3] There was no significant difference between traditional face-to-face classes and videoconference classes.

of overall interaction was a better predictor of student satisfaction with courses than personal interaction. We concluded when dealing with IMDL courses that it is best to plan for interactions, even those that occur during independent student learning activities.

Design Approach

The instructional design approach taken in developing the IMDL course was based on an eclectic constructivist epistemology (see Honebein, Duffy and Fishman, 1993; Jonassen, 1991, 1994; Savery and Duffy, 1995; Spiro, Feltovich, Jacobson and Coulson, 1991; Wilson, Teslow and Osman-Jouchoux, 1993; and, Gruender, 1996). Merrill (1991) summarized some of the tenets of constructivism as:

- Knowledge is constructed from experience.
- Learning is a personal interpretation of the world.
- Learning is an active process of meaning making based on experience.
- Learning is collaborative with meaning negotiated from multiple perspectives.
- Learning should occur in realistic settings (situated or anchored).
- Testing should be integrated with the task, not a separate activity.

On the surface open learning (constructivist) design principles appear to be in conflict with the distance learning paradigm, i.e., passing information/knowledge to remote learners, but we conclude specific features can be successfully applied. Various approaches are used to achieve student interactivity. Specifically, constructivist principles advocate learner involvement, but achieving such involvement at a distance requires distinct instructional design techniques. One technique that is implemented in the IMDL course is the proper use of questions to structure the learning environment and focus students' attention on both what they are learning and how they learn.

IMPLEMENTATION

Basic academic counseling was selected as a testbed course to demonstrate the features of the IMDL system. The goal of the course is for Air Force technical specialists about to become academic instructors to develop their skill as counselors. This goal does not mesh well with traditional distance learning instructional approaches which normally consist of factual information presented in a lecture format followed by a written test. Clearly, more interaction and practice was necessary to handle the counseling course. The technology being used in IMDL provided the opportunity to use a wide variety of instructional methods than are afforded by satellite-based *one-way* distance learning.

Distance education is most effective when the learning experience of the distance students is most similar to those at a local site with the instructor (Simonson, 1995). Many effective techniques used in non-distance classrooms have been modified for use with IMDL technology. Modifications were often made in the manner in which these methods were used as well. For example

Overhead transparencies or computer slides are often part of a tradition distance learning lecture. Generally, they are used to cover the information being presented point-by-point. Computer-based presentations formed the basis of much of the basic counseling course; however, they were used in a non- traditional manner in order to inspire student interaction. The slides frequently contained thought-provoking questions about the topic area to be covered, stirring discussion among the class. The instructor's role was to act as a facilitator, guiding students to various points in the lesson that may not have arisen during their discussion.

Cooperative groups or clusters were used throughout the course. During the cooperative activities, a camera was focused on individual groups, with audio from the groups occupying separate channels back to the instructor. The instructor could *listen in* to group activities or could speak to the group via the closed communications loop. One of the key activities performed in the small groups was counseling practice sessions. The class was divided into groups of three. In each group, one student would act as the counselor, one as the counselee, and the third evaluator of the counselor's performance. Evaluation was based on items developed by students during class and collected into an interactive behavioral evaluation checklist (to be discussed later).

The IMDL system whiteboarding capability was used in a manner similar to traditional classroom use of butcher paper and marker, or

the chalkboard. Student or groups could have their own page or the whole class could share a single page on the whiteboard. The page could be modified at any time by any student as well as the instructor. For example, one activity asked groups of students to identify characteristics of the best and worst instructors they ever had. The items were then listed on a groups' whiteboard page. The groups then presented these pages were then presented to the entire class and related the characteristics to the topic at hand, which was student motivation.

There was extensive use of video, both VHS and digitized, to highlight concepts. The computer-based videos were created specifically for this course. They displayed both correct and incorrect examples of counseling sessions as well as a wide variety of human behavior traits. Each video was from 10 seconds to approximately 5 minutes in length. This length of video would not typically be shown if a classroom VHS player had been used; however, on the student computers they were available at the click of a button. This allowed them to be conveniently used at the ideal moment in the course.

Computer-based games and puzzles were also used so that students could perform a self-evaluation of their learning progress. Although this method is similar to some very low-tech learning situations, the computers afforded increased options for student motivation. For example, the crossword puzzle game was accompanied by sound effects to indicate student progress. In another self-assessment game, an interactive version of *hangman*, when a student was successful completing a set of questions, they were rewarded with an animation of the *hangman dancing*.

Instructors have long used questioning as a form of student evaluation. Traditionally, one student is called upon in class to answer a question that has one correct answer. The IMDL approach took this method several steps further. Just like typical written tests, questions were written in multiple choice format. As students answer questions on their own computers, instant feedback is provided to the instructor of their response in form of a histogram (see figure 3). The instructor see a bar graph of how many student selected each response, as well as each individual student's selection. Based on these results, instruction can be modified immediately. If students understand the material the instructor can bypass items that would not contribute to their learning. If students are confused about the material, the instructor can tailor remediation based on the kind of mistakes students are making.

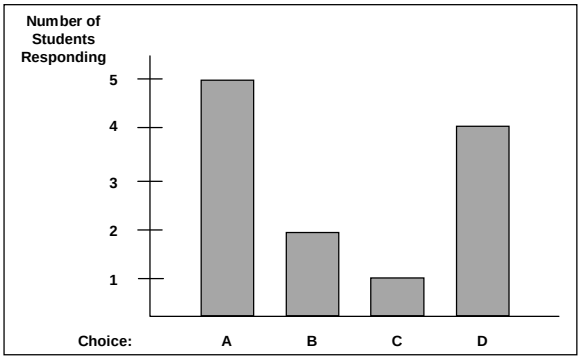

Figure 3. Histogram.

Although the majority of questions included in the course do have a correct answer, many do not. Some questions without a *single* correct answer were developed in order to stimulate discussion and encourage a deeper understanding of concepts. Care was taken to develop multiple-choice questions that dealt with the *application* of knowledge rather than just the memorization of factual information. An example of one such question, from the topic area of Human Behavior, is shown in figure 4.

A student in your class is acting irritable and has withdrawn from the other students. She is looking pale and drawn. Her grades have not been effected. You should:

A. Ignore it unless it affects coursework.

B. Call the student in for a conference and refer her to the correct agency.

C. Talk to the student informally before or after class.

D. Other. Be prepared to explain your answer.

Figure 4. Discussion Question.

Application of Counseling Skills

Approximately half of the time the students spend in the counseling course they are either counseling, being counseled, or evaluating mock counseling sessions. A Behavioral Evaluation Checklist (BEC) was used to enhance this process. It was developed to be used in the following manner:

1. Student clusters provide input about *ideal* counselor behaviors identified throughout the course.
2. Students share the behavior lists developed in small clusters with the rest of the class. The instructor consolidates these into a single list.
3. Students use sliding scales on the BEC to evaluate the degree to which each counselor behavior was exhibited during a counseling scenario (see figure 5).
4. At the end of each counseling session the *counselor* is provided the instructor's ratings and comments regarding their counselor performance.
5. The BEC compiles the evaluations given by the rest of the class and students also receive a summary of the entire class evaluation of their performance.

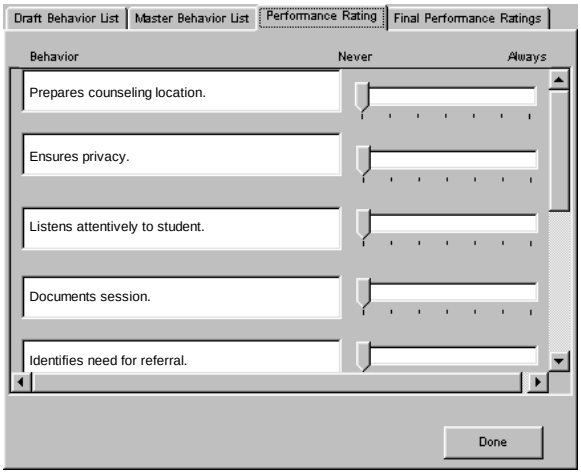

Figure 5. Behavioral Checklist.

CONCLUSION

Several lessons were learned from prior courses which used some of these techniques. Instructors cannot rely on their past face-to-face classroom experience as a model for conducting an IMDL course. Interactions are quite different at a distance and must be planned and practiced ahead of time. Instructors must spend sufficient time getting used to and practicing with the technology. When things don't go as planned (and they always don't), instructors who are comfortable with IMDL technology will be capable of adapting to the situation - just as instructors do in the familiar setting of a face-to-face classroom. Finally, instructional designers must build frequent, meaningful interactions into courses to hold student attention, to make all distance learning courses more directly applicable to student needs and to increase learning. We feel that the IMDL system and instructional design interventions briefly outlined in this paper begin to move in that direction.

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Note: At the time of publication, the system had not been tested with students. The presentation will include the results of early trials.