Assessing the Effectiveness of Interactive Compressed Video at the University of Minnesota

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Assessing the Effectiveness of Interactive Compressed Video at the University of Minnesota

Terry Kolomeychuk and Diane Peterson Peltz*

ABSTRACT

During spring 1991, the University of Minnesota implemented a pilot project in distance education using compressed video technology between the University of Minnesota Twin Cities and Morris campuses. Multifaceted in its exploration of the uses and capabilities of compressed video technology, this project was a shared venture of the Telecommunications Development Center (TDC) and the Minnesota Extension Service (MES).

Compressed video technology was employed to provide the instructional telecommunications link as it could be accommodated on the existing data link between the two campuses, which are geographically separated by 150 miles. Several projects suitable for using compressed video technology were solicited from MES. Those projects ranged in scope from education and training sessions to policy planning meetings. The general response to the sessions was overwhelmingly favorable in terms of the effectiveness of compressed video technology. Recommendations for use of the technology are given.

INTRODUCTION

"The characteristics of electronic communication -- physical separation, narrow communications channels, increased control, and dependence on technology -- increase the potential for both improvements and disappointments."

-- Smeltzer (1986, p. 38)

During spring 1991, the University of Minnesota implemented a pilot project in distance education using compressed video technology. The linkage was between two campuses of the University of Minnesota -- the Twin Cities campus in the metropolitan cities of Minneapolis and St. Paul, and the campus at Morris. The campuses are geographically separated by approximately 150 miles. (See Figure 1.)

Multifaceted in its exploration of the uses and capabilities of compressed digital video technology, the project was a shared venture of the Telecommunications Development Center (TDC) and the Minnesota Extension Service (MES). TDC's involvement related to its interests in exploring telecommunications technologies and their implications for distance education. MES saw the opportunity in this project to test a variety of educational and informational applications. (A description of the technology is found under "Background.")

The Minnesota Extension Service, part of the nationwide Cooperative Extension System, offers educational programs for adults and youth through a staff of on-campus faculty and off-campus county agents. This commitment of MES, an outreach unit, extends the resources of the University into all 87 counties in Minnesota.

MES anticipated several applications of the technology, from providing non-credit courses and continuing education programs to support and administrative services between locations. The five-month project examined these aspects of the technology:

1. the appropriateness of two-way compressed video versus two-way audio/one-way video applications;
2. the acceptability of compressed video for extension educational domains;
3. the nature and level of training required for effective use of the technology;
4. the technical compatibility of compressed video with existing analog interactive systems; and
5. the potential administrative uses of the technology.

Role of Distance Education

Distance education has its historical foundation in correspondence study and originally implied a physical and temporal separation of teacher and learner, where the learner is independent of contact with teacher or other students. The introduction of telecommunications technology to distance education implies a simultaneous delivery of information and/or instruction from one or multiple sites to many other sites, coupled with audio and/or video interaction between all sites. The emergence and development of sophisticated communications technology and the renewed interest in lifelong learning are major factors in the new prominence that distance education has achieved. Learning has come to be recognized as a lifelong process in which individuals are using alternative informational/instructional materials in a variety of formats that permit the integration of learning with other life roles and responsibilities. People are taking a greater responsibility in structuring the nature and type of learning opportunities. Distance education in North America has been identified as a great...
advance in adult education, reaching learners outside the conventional educational system through mediated forms of instructional delivery (Draper, 1987). Morrison (1988) states that distance education has the potential to address societal changes and the resulting changing relationship between higher education and the broader society. Morrison also states that distance education: 1) is an alternative learning system, 2) blurs roles and functions, 3) accommodates time and space realities of part-time adult learners, 4) provides lifelong learning opportunities, and 5) utilizes a range of methods for transmitting information.

Much of the current focus of distance education technologies has been on broadcast and satellite technology, largely passive applications. Research in distance education has compared the effectiveness of one delivery system or technology over another. Dillon et al. (1991) found no significant learning differences between compressed video and other technologies. Chu and Schramm (1975) concluded that the question to be asked is not whether to use the technology, but rather how best to use the technology. However, Griffin and Hodgins (1991) question the effectiveness of the technology, citing a U.S. Navy evaluation of the results of interactive video-based training. The Navy study identified three main deficiencies in the interactive video medium: 1) quality of the video presentation, 2) quality of the audio portion, and 3) instructor-student interaction at remote sites.

The challenge of this pilot project was to determine the best applications for the relatively new technology of interactive compressed video.

**Figure 1**

Location of University of Minnesota Campuses and the Rochester Center

**BACKGROUND**

**The University and Instructional Telecommunications**

Over the past decade, University of Minnesota committees have dealt with issues relating to instructional telecommunications. Prompted in part by the recent interest of the State of Minnesota in establishing a statewide telecommunications network for government and education, the University initiated further discussions regarding this application of instructional telecommunications. The University has not used distance delivery technologies extensively, nor has it supported a large number of distance delivered programs.

However, some use of distance delivery technologies has occurred. Undergraduate independent study courses, via videotape or audiotape cassettes, have been offered for some time, and a small number of undergraduate and graduate courses have been delivered via broadcast television or radio (Kovel-Jarboe, 1989). Distance delivery has also been used for MES county agent training and special programming.

To improve service to its coordinate campuses, the University (University of Minnesota, 1990) identified five distinct kinds of learning needs to be addressed through instructional telecommunications:

1. undergraduate education, especially upper division;
2. graduate education within the College of Graduate Studies;
3. other post-baccalaureate credit education;
4. continuing professional education; and
5. informal (non-credit) education and enrichment.

As a result of the combined interest in distance education and the use of instructional telecommunications, four related courses of action were recommended:

1. development of a strategic plan for instructional telecommunications;
2. identification of permanent facilities for the origination and reception of instructional video;
3. establishment of program advisory boards; and
4. the implementation of a pilot project which would use interactive compressed video (by spring 1991).

**Strategic Plan for Instructional Telecommunications**

A strategic plan for University instructional telecommunications was developed but has yet to be implemented. Permanent facilities for the origination and reception of instructional video are part of the plan. The compressed video initiative, as with the establishment of program advisory boards, is expected to be phased in over a three-year period. During this same time period, compressed video technology will be phased in as compressed video links are established between the coordinate campuses at Morris, Crookston, and Duluth, and at the Rochester Center. The establishment of program advisory boards has yet to be done pending the outcome of the pilot project.

Compressed video technology was used to provide the instructional telecommunications link as it could be accommodated on the existing T1 data link (a 1.54 megabit/second dedicated telephone line) already in place between the two campuses (Morris and Twin Cities). The University’s T1 link was under utilized at the time of the pilot project and the incorporation of this technology provided not only an opportunity to examine the issues and needs of instructional communications between the campuses but allowed for a maximization of existing resources.

**Compressed Video Technology**

Video compression technology provides for interaction using
both video and audio. Existing digital telephone lines are used as the medium of transmission. Advances in video compression are extending the use of video applications in business television, education, and direct satellite broadcast. Video compression will reduce transmission costs and increase satellite capacity tenfold. It has the potential to make DBS (Direct Broadcasting Satellite) service a reality, put videophones in every office, provide a means of delivering high definition television, place video on compact disks, and provide the catalyst to launch ISDN (Integrated Services Digital Network), a digital telecommunications channel that allows for the integrated transmission of voice, video, and data.

Compressed video technology reduces the amount of information in a video signal so that it can be transmitted over standard digital telephone circuits. This technology has been in development for about 20 years. Significant strides have recently been made in delivering good picture and sound quality when large quantities of the video signal have been removed for transmission. In North America and Japan, a standard television screen (NTSC) has 525 lines that are transmitted as part of the signal. This translates into a television picture that has about 430 x 480 pixels (picture elements) of information. Each of these 200,000 or so pixels are given updates about its color and brightness 30 times a second. It is this constant updating of every pixel of information that creates the demand for a lot of transmission space (bandwidth) on a telecommunications system. A normal broadcast signal requires the equivalent of 1400 phone lines for transmission. Compressed video requires the equivalent of 1 to 24 phone lines depending on the rate of compression. The image compression/translation is accomplished by a codec (coder/decoder) which digitizes the analog video signal and compresses it by means of an algorithm that determines what material is redundant and what is to be transmitted. The digital information is analyzed, processed, and communicated to another codec where the redundant information is replaced, and the signal is reassembled and converted to analog again for viewing.

As the amount of bandwidth required for videoconferencing is reduced the number of locations that can be reached by that signal increases. Digital video transmission can travel long distances without picking up any signal noise as is the case with analog video transmissions that get increasingly noisy (snowy) as the signal is processed along the transmission path. Also compressed video can run on copper phone lines already in place and, with the advent of dial up T1 and fractional T1 services, the accessibility will only increase.

The driving factor toward increased accessibility and lower codec prices will be the new H.261 international video conferencing standard, adopted by the International Telegraph and Telephone Consultative Committee in 1990. All major suppliers of videoconferencing systems have pledged support for the new standard, which is aimed at giving users of disparate videoconferencing systems a common algorithm. Domestic video conferencing systems today are not compatible with each other because they operate with proprietary algorithms. The major domestic vendors will soon offer multimodal devices that will go through a handshake process -- searching for and finding a compatible algorithm -- that will use the proprietary algorithm if all systems on the conference are alike or will switch to the H.261 algorithm if that's the only common conferencing mode available. Vendors will continue to shift to the desktop, whether it be in the form of personal-based video conferencing systems or migration plans toward multimedia systems, which integrate full-motion video with audio, data, and graphics. Compression Labs and PictureTel, the two leading suppliers of videoconferencing communications systems, both are expected to introduce PC-based videoconferencing systems and videophones by 1992.

Better video quality at lower transmission or bandwidth rates, worldwide standards, equipment compatibility, and reduction in cost for both transmission and hardware will make videoconferencing a viable communications instrument, much like fax (facsimile transmission) or personal computers.

**PROJECT OVERVIEW**

Several applications suitable for piloting compressed video technology were solicited from MES. They ranged in scope from education and training sessions to policy planning meetings. Perhaps the most difficult challenge was to find groups and individuals to use this new technology. However, several groups that participated in one session came back for a second try at using the medium. Participants were confined to using the two-way studios at Morris and Minneapolis campuses, and two buildings on the St. Paul campus via coaxial cable. The cost of running the pilot project was approximately $10,000 for the MES applications. The average cost per production was $1,400.

Audiences for the project included county extension agents, MES staff and faculty, MES Citizen's Advisory Council, faculty in the Department of Agricultural and Applied Economics, tree workers, rural economic development representatives, telecommunications experts, policy developers, and Morris business leaders.

The applications included:

**Application 1.** An April 11 meeting of two MES multi-cluster districts -- the Southwest (Lamberton) and West Central (Morris) -- and the MES Citizen's Advisory Council in St. Paul, originating from the Earle Brown Center on the St. Paul campus. The MES dean and director made a presentation to the three groups and provided for a question-and-answer session among the groups. The session also provided an opportunity to demonstrate this new technology to the advisory group. The compressed video link was used to provide an interactive video and audio conference between the Morris campus (West Central cluster) and the Earle Brown Center, St. Paul Campus (Citizen's Advisory Council). The Southwest Cluster (Lamberton) was linked to the other two sites by audio link only. The meeting was attended by 30 people at the Earle Brown Center, 39 at the Morris campus, and 36 at Lamberton.

**Application 2.** A May 14 meeting on Community Development Corporations (CDC) using the compressed video system was convened to exchange information and concerns with regards to CDCs in Greater Minnesota (i.e., rural Minnesota). The session included three participants at Morris and six at the Twin Cities location (Rarig Center). A follow-up session using the compressed video link was held July 18 as part of the Minnesota Banker's Association meeting in Morris.

**Application 3.** As part of a MES horticultural program, a half-day seminar for tree workers on June 14 was offered in both Morris and the Twin Cities. The seminar was attended by 85 people (mostly tree inspectors from the surrounding metropolitan counties) who met in Borlaug Hall on the St. Paul Campus, and 10 at the Morris campus. This was the most technically extensive and complicated transmission due to the location of Borlaug Hall, the number of slides and visual displays, and the extra equipment needed for transmission.

**Application 4.** A June 24 planning meeting in advance of a conference on rural telecommunications policy was convened at the Hubert Humphrey Institute on the Minneapolis campus. Four people attended at the Morris campus and 19 people at the Rarig Center. The planning meeting lasted about two hours, and a follow-up meeting
was arranged in August using the video conference system.

Application 5. As a component of the Agricultural Lenders School, University of Minnesota at Morris (July 16–18), a business retention and expansion program was introduced to the participants facilitated by the compressed video link on July 18. The hour-long introductory session was attended by 54 people in Morris and six people at the Rarig Center in the Twin Cities. This was the first session of the pilot that had Morris as the originating or host site, and it was the first meeting in this series that was chaired from Morris. A well-balanced and carefully thought out agenda was arranged in advance with plenty of time for questions and answers, allowing for interaction from the participants and audience on both campuses.

Application 6. As a follow-up to the June 24th rural telecommunications policy meeting, a second session was convened on August 12. It was attended by eight people in Morris and 12 at the Rarig Center in the Twin Cities.

EVALUATION

"Teleconferencing serves as prototypical example of how electronic instructional delivery systems can give greater access to existing instructional resources. Not only can teleconferencing stretch the availability of existing personnel, but it can also link geographically dispersed groups."

-- Wagner and Reddy (1987, p. 49)

Evaluation Methodology

A standardized questionnaire was administered to 276 participants (260 participants responded, representing 95 percent of the total) at the Twin Cities and Morris sites. The critical question which guided the development of the survey was whether interactive compressed video is an effective and appropriate medium for expanding participation in information and educational exchanges between the two sites.

In evaluating the interactive compressed video system for use in extension activities and programming, the following additional questions were of interest:

- How does compressed interactive video compare to other forms of video conferencing?
- How acceptable is compressed video in terms of delivering Extension programs?
- What is the nature and level of training required to effectively use the system?
- What is the ideal size of groups for this type of distance learning system?

A one-page, five-item questionnaire asked participants to rate the effectiveness of the sessions (workshop/program/meeting) vis-a-vis the technology. Question 1 rated the technology in terms of its effectiveness in delivering the information, question-and-answer session, graphic capability, and its ability to provide for group interaction between the sites. Question 2 asked respondents to rate the physical qualities of the medium, as to video and audio quality, physical facilities of the meeting room including visibility of monitors, and the technology's ability to promote interaction and participation. Question 3 rated the appropriateness of the technology for the type of meeting or session being held. The three questions used a four-point Likert attitude scale and asked participants to measure their intensity of agreement to the statements. The final two questions were open-ended to ascertain the advantages and disadvantages of compressed video and the technical and learning problems associated with using this technology.

Evaluation Findings

The general response to the sessions was overwhelmingly favorable in terms of the effectiveness and the appropriateness of the technology. (See Table 1.) It appears that the participants want to embrace the technology if the technical problems can be overcome. The response to the use of interactive compressed video to facilitate interaction between Morris and Twin Cities was positive, with the majority of responses in the good to excellent category. Generally the more favorable responses came from the host site, which in this project was the Twin Cities site in four of the applications and the Morris site in two. The first question was designed to solicit responses in terms of the type of sessions being facilitated to determine some best uses for the technology. The most positive responses came from the smaller sessions, where the number of participants was limited and the opportunity to share information was increased.

The technical quality of the sessions, particularly the audio and video components was rated good to fair by three fourths of the respondents. The physical arrangements for the sessions scored higher, where three quarters of the respondents indicated a good to excellent

Table 1

Summary of Participants’ Responses to Interactive Compressed Video Sessions

(N=260)

<table>
<thead>
<tr>
<th>Question</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How would you rate the effectiveness of this technology with regard to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>presentation of material</td>
<td>37%</td>
<td>47%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>question-and-answer session</td>
<td>45%</td>
<td>45%</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td>graphics</td>
<td>22%</td>
<td>48%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>small group interaction</td>
<td>32%</td>
<td>52%</td>
<td>13%</td>
<td>3%</td>
</tr>
<tr>
<td>2. How would you rate the following:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>video quality</td>
<td>10%</td>
<td>45%</td>
<td>20%</td>
<td>5%</td>
</tr>
<tr>
<td>audio quality</td>
<td>8%</td>
<td>44%</td>
<td>28%</td>
<td>20%</td>
</tr>
<tr>
<td>physical facilities (e.g., seating)</td>
<td>42%</td>
<td>40%</td>
<td>14%</td>
<td>4%</td>
</tr>
<tr>
<td>visibility of monitor(s)</td>
<td>40%</td>
<td>40%</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>opportunity to participate</td>
<td>36%</td>
<td>48%</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>3. Is the technology for this type of meeting...?</td>
<td>Very appropriate</td>
<td>Somewhat appropriate</td>
<td>Appropriate</td>
<td>Not very appropriate</td>
</tr>
<tr>
<td></td>
<td>56%</td>
<td>24%</td>
<td>17%</td>
<td>3%</td>
</tr>
</tbody>
</table>
rating. The technical quality of the sessions appeared to be the most limiting factor for most people, particularly the audio quality. While most participants could tolerate less than perfect video signals, the problems encountered by the audio components had a more profound effect on how people rated the technology and its ability to facilitate interaction.

The majority of respondents (56 percent) rated the use of compressed video as very appropriate. The ability of this technology to bring together urban and rural parts of the state in an interactive two-way environment was key to the high rating and acceptability.

The potential of this technology is the capability to bring people together face-to-face in small group interactions. As one respondent stated, "It was better than an audio conference because we could see them." The general reaction of participants from both the Twin Cities and Morris locations was one of enthusiasm for the potential of this technology to bring groups together over distance for matters and issues of common concern.

Participants found the following advantages with compressed video:

- increased access to state and regional experts;
- decreased travel time and cost;
- reached more people;
- access to timely information;
- interaction with experts;
- interaction with peers; and
- group size can vary.

Disadvantages included:

- technical problems;
- lack of personal interaction between the sites;
- television style production, particularly at the Twin Cities sites, reduces informality of meetings and increases stress on participants to perform;

Box 1

Recommendations from Compressed Interactive Video Project

1. Physical Setting and Creature Comforts

This pilot project focused on the applications of the technology and physical space, and capabilities were determined by existing facilities. All the things that would go into organizing a good meeting or training session have to be included in Interactive compressed video. Including working height tables, comfortable chairs, refreshments, and other creature comforts. The technical requirements for video are the minimum requirements for a successful session. Communication of the information between groups is still the key to a good meeting and a good video conference. Neither the technology nor the physical facilities can overcome lack of interpersonal dialogue during sessions.

2. Site Interaction

The greatest challenge in Interactive video Instruction, or meetings, is overcoming the barriers of distance and technology that hinder normal personal interaction. This interaction may be negatively affected by the novelty or fear of technology, number of participants or students and/or sites included in an event, decreased ability to receive non-verbal cues from participants, limited opportunity for after-meeting or after-class discussions, and preconceived notions about television viewing (e.g., a passive activity).

A high level of interaction is important in teaching and learning and in meetings in order to increase the attention and motivation levels. Interaction can also be used to determine whether the information and concepts being presented are properly received and interpreted. It is recommended that leaders, participants, instructors, and students become confident (through exposure and training) using the technology, limit the number of participants/sites, evaluate course and instructional design, establish interpersonal rapport, find activities that promote involvement, and establish new questioning strategies to promote interaction with the audiences (Tykwnski and Poulin, 1991).

3. Audio Problems

Technical problems dominated the sessions. The problems were characterized by audio-related problems in all instances. This created a real problem for interactivity as audio problems prevented spontaneity and interaction. The audio problems encountered included distorted audio transmission, the failure of the echo canceler, and a general dissatisfaction with the sound quality. Audio problems are less acceptable than video difficulties.

4. Monitor Size

Because participants depend on visual cues for interpersonal communication, monitor size has been a problem especially when the sites have large number of people attending. Because of the lower quality of the compressed video signal, 28-inch monitors do not have the visibility required to give presence to the participants at the other sites. Video projection systems have been suggested as an alternative.

5. Production Capabilities

The capabilities of the two facilities at Morris and Rarig Center (Twin Cities) differ in both the level of production values needed and the number of staff required to undertake the project. The infrastructure at Rarig Center lends itself to a more television-style production and the technical needs of the event dominate over the need to promote interaction between the sites. By and large, the Morris staff appeared to treat the interactive video sessions with less of a "video production" mentality and more of an informal session where the video component is the means to facilitate the interaction between the two sites. The production capabilities question is closely related to the need for permanent facilities.

6. Permanent Facilities

Permanent facilities for the continued use of the compressed video link are required to eliminate the constant set-up for these sessions. A lot of the technical problems seem to occur as invariably the crew changes and, with it, past experience. Participants should be able to slide effortlessly into the meeting situation without the need for production cues and formalities. A permanent facility is currently being installed at University Media Resources in the Rarig Center in Minneapolis. This interactive classroom is flexible in scope and based on Interactive video design. It will have multiple uses including classroom and video conferencing applications. The amount of interaction will undoubtedly increase without the presence of crew members and technicians in the room.

7. Group Size

Group size has played an important role in the interactivity of the sessions. By and large the sessions with more equal number of participants in both locations produced the best results in inter-group interactivity. The smaller the meeting the better the interaction. Larger sized groups have increased the production problems in terms of accommodating large group interaction. Audio pick-up from large groups is a problem. In large groups where participants are addressing both sites, maintaining eye contact with both the remote site and local participants has proved to be a problem. People at the remote site have felt excluded from the discussion as the speaker addresses comments to the local participants, to exclusion of the remote site.

8. Support

There is a need for coordination, promotion, and training for the compressed video system. A large part of the development time spent in organizing each session was promoting the system for use among potential users. Coordination of time and facilities between the two sites was required, especially when the sites in the Twin Cities were at temporary locations other than Rarig Center. Also, potential users need help with organizational items such as agendas, presentation standards for graphics, and using group interaction skills for the meetings. These six sessions demonstrated the need for training, and a way to explain the capabilities and the limitations of compressed video so as to match needs to the technology for optimum results.

9. Compatibility

Minnesota has a number of interactive television networks developed by educational systems. These networks, for the most part, are not interconnected and generally serve either one or a coalition of school districts defined by geographical location. The systems generally are full-band analog using fiber optics as their means of interconnection and transmission. Interconnection is possible and switching between analog and digital systems is feasible. The audio component would require the most adaptation to accommodate the delay in the sound transmission. These systems will improve their ability to interconnect and eventually provide statewide accessibility.
meeting in television studios is not great for creature comforts; 
size of monitors used for incoming signals is too small; and 
increases separation and lacks presence in participating loca-
tions.

CONCLUSIONS

As a result of the analysis of the evaluations, nine conclusions 
were drawn by the project directors. (See Box 1.) The conclusions are 
in the areas of: 1) physical setting and creature comforts, 2) site 
interaction, 3) audio problems, 4) monitor size, 5) production capabili-
ties, 6) permanent facilities, 7) group size, 8) support, and 9) compatability

Future Direction and Research

The use of interactive compressed video conferencing systems 
for distance learning will no longer be confined to those who have 
private networks. The technology will now open to a much broader 
range of users, in large measure due to the widespread availability of 
dial-up switched services from the local telephone company and the 
emerging capabilities of Integrated Services Digital Networks (ISDN).
Cost of the technology, currently a concern is expected to decline 
rapidly with the introduction of desktop, PC-based codecs.

Improvements in codecs that drive videoconferencing systems 
now make it possible to compress digital video images so they can be 
transmitted at lower data rates. Bandwidth on demand is now available 
for videoconferencing users who want to transmit at lower data rates.
What makes the service unique is that it is similar to placing a 
telephone call. The pace of change in the video compression industry 
will be staggering; the integration of video, voice, and data into multi-
media communications is the wave of the future.

The move to this type of user-actuated service will do much to 
 improve access to information for a wide spectrum of people. Learning 
and information sharing can truly become an on-demand service, 
both in a timely and efficient manner that suits the user. For MES, it 
offers a low-cost alternative to broadcast or satellite delivered pro-
gramming. For an organization like Extension that is the outreach arm 
of an institution, it is important to incorporate this technology in its off-
campus programming.

Video conferencing is being applied in all areas of education and 
government. It serves the needs of "distance learning" institutions, and 
as users become more sophisticated and comfortable with the technol-
logy, other innovative applications will appear.

Issues of site interaction are more complex and will require 
further study, including participants attitudes and behavior in using 
interactive technologies. The best mix of participants at various sites 
and the most suitable meeting/classroom configuration for distance 
learning also needs to be studied.

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