

Videoconferencing in  
Kindergarten-to-Grade 12 Settings:  
A Review of the Literature

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## VIDEOCONFERENCING RESEARCH COMMUNITY OF PRACTICE

This research review was conducted to provide information that would inform Alberta Education and school jurisdictions in their future work regarding videoconferencing initiatives in Kindergarten to Grade 12 schools. Although direction was given to the researchers/writers to establish parameters for the task, the content of this document reflects the writers' perspectives on topics reviewed, and does not necessarily reflect the position of Alberta Education.

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## EXECUTIVE SUMMARY

In this report, we present a review of the literature on Internet Protocol (IP) videoconferencing in Kindergarten-to-Grade 12 (K-12) settings. The review is part of a larger, one-year project that includes several stakeholders and multiple goals. The objectives of the larger project are to describe the use of videoconferencing in five Alberta school jurisdictions, understand how this technology is being used to enhance teaching and learning, and to develop a community of practice surrounding its use throughout the province. The role of the literature review therefore is to situate the researchers' case studies, provide evidence-based resources for teachers, technical support personnel, and administrators; and to inform the decisions of policy makers.

The review is comprehensive and includes articles from 1991 to 2004. We confined our review to empirical reports (reports in which data was collected and analyzed systematically) published through the peer review process. We identified the reports through a hand search of several educational journals and an electronic search of several databases of educational research. The search yielded 53 articles that fit our criteria.

The meager empirical research in this domain is a reflection of two things. First, the use of videoconferencing in K-12 settings is a relatively new phenomenon. Even newer is the use of the Internet as the network infrastructure that supports this technology. Second, the bulk of writing in this area consists of anecdotal reports, project descriptions, and informal case studies—a type of dissemination that is endemic to the early stages of technology implementation.

Consequently, we have insufficient information with which to offer definitive conclusions about the use of videoconferencing in K-12 settings. Our review therefore provides a survey of six topics that are recurrent in the literature, including 1) outcomes, 2) learning activities, 3) interactive learning processes, 4) keys to success, 5) special populations, and 6) equipment and technology.

- The research on outcomes focuses on two topics - achievement and attitudes. Data collection and analysis techniques on these topics are largely subjective and reports are typically encouraging, though this one-dimensional finding is less informative or persuasive than a more complex treatment might be.
- Learning activities that are described frequently include virtual field trips, multi-class collaborative projects, cross-cultural exchanges, and content delivery. The latter activity often originates in rural and remote schools that have an immediate need to provide curriculum to their students; the former activities often reflect the desire of urban schools to enhance their students' classroom experience.
- A few researchers have studied these activities closely and report on the processes in which students engage while participating in these activities. Participation, interaction, dialogue, and collaboration are the focus of these studies. Surprisingly, measurement instruments and assessment rubrics developed to measure similar processes in other technology-supported interactive learning environments are not utilized in the

videoconferencing literature.

- “Keys to success” is also a common topic in the literature. Though the suggestions are rarely supported by empirical evidence, the convergence of anecdotal reports on a common set of principles lends weight to several recommendations. Support - technical, pedagogical, administrative, and financial - is the primary counsel provided by experienced participants.
- Special populations are perennial constituents of the distance education and educational technology milieu. Several reports discuss the use of videoconferencing to provide accessible and equitable educational experiences for special populations.
- Discussions of equipment and technology, which are inevitable for practitioners, are tangential elements in most case study reports. Perhaps researchers have been reluctant to engage in complex descriptions of proprietary systems, local configurations, and unique equipment. Those who do, point out that in educational settings, videoconferencing always involves a constellation of equipment and technology including, video capturing devices, display devices (television monitors and projection screens), document cameras, personal computers, electronic whiteboards, and more. When equipment or technology does surface in reports, it is often because it has been noticeably unreliable, and is accompanied by suggestions for dedicated, sophisticated technical assistance.

## INTRODUCTION

Videoconferencing has been available since the 1950s (Lochte, 1993), but until recently its role in public K-12 education has been marginal. Its traditional home has been in corporate training, post-secondary distance education, and rural and remote school districts. Recently, this situation has begun to change as several large-scale, national and international projects have introduced videoconferencing to the K-12 system and changed the way it is used in traditional environments (Advanced Broadband Enabled Learning, 2004; Rural Advanced Community of Learners, 2004; Green, 1999).

In the coming years, these projects will affect the lives of many students, parents, teachers, technical support personnel, and school administrators. It is important, therefore, to proceed in a manner that affords the best opportunity for success. Building on the knowledge and experience of others who have already undertaken similar projects is an essential part of this process. A dedicated group of K-12 practitioners and researchers have documented their experiences with videoconferencing so that others may learn from them. In this paper, we have collected the most trustworthy of these reports, abstracted relevant information, and synthesized the information into a coherent summary.

Our literature review includes four sections. In the first, we provide a general introduction to videoconferencing and its eventual implementation in mainstream K-12 settings. In the second, we provide a brief discussion of our strategy for conducting this review. Following this, we move to a presentation of the literature on videoconferencing in K-12 settings. (Hereafter, the term *videoconferencing* should be understood to refer specifically to *IP videoconferencing*). The presentation is organized around six topics that are recurrent in the literature: outcomes (achievement and attitudes), learning activities (virtual field trips, collaborative projects, cross-cultural exchanges, content delivery), interactive learning processes, keys to success, special populations, and equipment and technology.

## OVERVIEW

Videoconferencing is an educational technology that overcomes many of the objections that people have to providing education in any setting other than the face-to-face classroom. It overcomes the lack of interaction associated with correspondence study, it provides a rich repertoire for communication unlike computer conferencing and audio conferencing (Motamedi, 2001), and it allows teachers and students to engage in the types of teaching and learning activities to which they are accustomed, if that is what they want to do, and if that is where they want to begin.

Why then are these other technologies more prevalent than videoconferencing? In the past, there have been problems with videoconferencing. It has been expensive - the cost of videoconferencing over telephone lines is equivalent to the cost of six long distance calls (per site) for the duration of the event (Kegel, 2004; Kinginger, 1999; Litterst, 2004; Parrot, 1995); it is complex; and the collection of sophisticated equipment associated with videoconferencing can be daunting to those who are already engaged in complex activities, namely, teaching and learning. Steadily, these issues are being resolved.

Complex compression algorithms reduce the amount of bandwidth that videoconferencing requires. Moreover, the ubiquity of high speed, high bandwidth networks, like the Alberta SuperNet, make bandwidth less of a concern. At the same time, efforts to standardize and humanize many aspects of the technology that were once idiosyncratic and proprietary, diminish its complexity.

It is the combination of these factors that have precipitated the introduction of videoconferencing into mainstream educational settings. To facilitate this transition, we have compiled a review of relevant research on K-12 videoconferencing and have presented it in a form that is accessible to practitioners. We begin the review with a description of how we selected the articles for our review.

### METHODOLOGY

The purpose of this paper is to review literature resources and summarize research findings relating to the use of videoconferencing in K-12 settings. To this end, we conducted hand searches of several educational journals and electronic searches of online educational databases. The databases included:

- Educational Research Information Clearinghouse (ERIC)
- Digital Library of the Association for the Advancement of Computers in Education (AACE)
- Academic Search Elite
- Dissertation Abstracts International
- The World Wide Web

Our initial search returned 311 results. After reviewing these citations, we determined that 145 resources could potentially be included in our review. The 145 resources were carefully reviewed to evaluate each study's quality and research focus. Following this inspection, we settled on 53 articles. The publication dates range from 1991 to 2004.

In order to serve the information needs of our stakeholders, we selected an unconventional format for presenting our review. Borrowing a format from the British Educational Communications and Technology Association, we have summarized the literature in the following manner. The review is divided into the six topics listed previously. Each topic begins with a short summary followed by a terse abstract of relevant studies.

Our first topic is outcomes, which entails a discussion of achievement and attitudes.

### OUTCOMES

One of the first questions that stakeholders ask of any new educational innovation concerns its effect on achievement. Videoconferencing has not escaped this scrutiny. Unfortunately, researchers have not shown similar levels of interest in this question. Moreover, when achievement is studied, it is often studied in ways that are not persuasive to audiences. Only one

study in our collection addressed the persistent demands for objective analyses of student achievement. Hepburn and McMillan's (2004) quasi-experimental study offers a comparison of year-end student achievement across four modes of distance delivery (classroom, correspondence study, audiographics, and videoconferencing). Their interpretation of the efficacy of videoconferencing is positive; however, others may reach different conclusions from their data. Green (1999) and Stromsland (1999) offer subjective analyses of the influence of videoconferencing on outcomes. Their assessment of students' and teachers' perceptions of achievement, which are also positive, are more reflective of the general approach to studying achievement in this domain.

Attitudes toward videoconferencing are a common focus in outcomes research (Arnold, Cayley and Griffith, 2002; Siraj-Blachford & Siraj-Blachford, 2001; Yost, 2001). These focus entirely on the attitudes of students and teachers (with conflicting results); we did not find any studies that surveyed the attitudes of parents or administrators, two groups among many that have a stake in the implementation of videoconferencing programs.

In addition to attitudes, the study by Arnold et al. (2002) points to an uncelebrated but central outcome in videoconferencing programs: *access to*. For many rural and remote schools, access to educational experiences equivalent to those of their urban counterparts is the driving force behind their videoconferencing programs. For the urban schools, as Arnold et al. describe, access to experiences and resources that enhance the curriculum are central to their videoconferencing programs.

Technology skills and communication skills are often cited as outcomes in anecdotal accounts of videoconferencing, yet they not well represented in the literature. Project descriptions often conclude with enthusiastic descriptions of how students have improved their presentation or group work skills or have improved their fluency with the technologies they are required to use. In our review only Siraj-Blachford and Siraj-Blachford (2001) and Yost (2001) address this topic.

#### OUTCOMES: ACHIEVEMENT, ATTITUDES, ACCESS TO, SKILLS

Arnold, Cayley and Griffith (2002) survey ten case studies and provide information on preparing for and implementing videoconferencing programs. The authors identify several positive impacts including increased collaboration between schools; enhanced language learning; increased accessibility to learning opportunities; inclusion of subject experts and specialized experts into classroom study; enhanced multicultural exchanges; establishment of links between schools, industry, and the community; and increased access to professional development opportunities for teachers. Evaluations provided by participating teachers and students were generally supportive of videoconferencing.

Cavanaugh (2001) conducted a meta-analysis of K-12 distance education studies published between 1980 and 1998. Focusing on instructional activities and interactions between the attributes of learners and technologies, she identified differential outcomes for two distinct approaches to distance delivery. Programs that used interactive technologies such as videoconferencing to enhance traditional instruction yielded greater effects on achievement than

programs that used interactive technologies as the primary tool to deliver instruction. Cavanaugh concluded that interactive media are most effective when they are used moderately, to achieve specific goals, in combination with other methods and activities.

Green (1999) evaluated a large literacy project funded by the U.S. Department of Education in which a collaborative learning environment was established between eleven K-12 schools. Green's assessment of the project after four years of operation showed that students had made substantial gains in English reading proficiency. In addition, the percentage of students who successfully completed their college preparatory coursework increased. The author also notes that attendance was higher for students who participated in the project than it was for those who did not.

Hepburn and McMillan (2004) conducted an economic evaluation of a videoconferencing program in a northern, rural, remote school district. Each of the district's five high schools was equipped with sophisticated videoconferencing suites that included document cameras, electronic whiteboards, multiple monitors, cameras, microphones, personal computers, and desktop videoconferencing units for each of the personal computers. Hepburn and McMillan estimated the annual cost of the suites at \$445,000. To conduct a cost-effectiveness analysis, they also collected year-end achievement data on students whose courses were delivered entirely through the videoconferencing suites, and they compared this with similar data from students in the district who took face-to-face courses, correspondence courses or audiographics courses. The authors employed a quasi-experimental research design and processed their data using quantitative data analysis techniques. They conclude that when costs and student achievement are considered together, videoconferencing delivery was more cost-effective than the alternatives. Hepburn and McMillan provide sufficient data for readers to draw their own conclusions.

Siraj-Blatchford and Siraj-Blatchford (2001) explored the use of videoconferencing with young children using the technology as a free play activity. The use of videoconferencing increased the children's awareness and understanding of the technology but did not lead to the anticipated developmental gains. Often, the authors report, the children's use of the technology was brief and frustrating. The authors speculate that developments beyond technological awareness would require additional activities, support, and some form of cognitive apprenticeship.

Stromsland's (1999) doctoral dissertation focuses on the perceptions of fourth- and sixth-grade students who used videoconferencing as a learning tool. Her results showed that videoconferencing was effective in increasing the students' perceptions of their ability and achievement scores, and that the effect persisted across grades and gender.

Yost (2001) evaluated the use of videoconferencing with young children. Two kindergarten classes participated in daily videoconferencing interactions. The author concludes that the children enjoyed the experience, increased their understanding of technology and enhanced their awareness of their environment.

## LEARNING ACTIVITIES

One of the earliest extensively studied and celebrated K-12 videoconferencing projects was Roy Pea's Collaborative Visualization project, or CoVis (Pea, Gomez, & Edelson, 1995; Pea, Edelson, & Gomez, 1994; Pea, Edelson, & Gomez, 1994). Working in the mid 1990's with rudimentary desktop videoconferencing technology, Pea and his colleagues developed a highly successful program for helping high school students learn science. At the time, constructivist perspectives of teaching and learning were just gaining currency, and Pea's idea was to use videoconferencing to connect students to working scientists. He demonstrated that this was a more effective way to learn than memorizing well-established facts. Collaborative projects of this nature continue to appear in the literature. Shaklee's (1998) doctoral dissertation, for instance, examines the influence of a similar activity on students' epistemological beliefs.

Most of the projects reported in the literature, however, focus on collaborations between classes. Gage, Nickson, and Beardon (2002), Green (1999), and Thurston (2004) show that collaborative activities can assist primary, elementary, and high school students with subjects such as Math, reading skills, and English proficiency.

Another common form of collaboration is discussed by Cifuentes and Murphy (2000) and Gerstein (2000). These authors describe cross-cultural exchanges, which are undertaken successfully to develop students' multicultural awareness and understanding.

Barshinger and Ray (1998), Pachnowski (2002), and the Ward Melville Heritage Organization (2002) report on the use of videoconferencing to take students on virtual field trips. The authors demonstrate that compared to conventional field trips, there are fewer concerns about costs, transportation, safety, and time.

### LEARNING ACTIVITIES

Barshinger and Ray (1998) studied the use of videoconferencing to prepare fifth-grade students for a museum visit. Building on the students' and the teacher's interpretations of the experience, the authors report that, as a type of advance organizer, the orientation was successful in promoting cognitive and affective outcomes stemming from the field trip.

Cifuentes and Murphy (2000a) evaluated the effectiveness of distance learning and multimedia technologies. Students in grades five-to-eight participated in collaborative activities and shared multimedia files during interactive videoconferences. The use of technology was found to facilitate an expanded learning community. Teachers developed empowering multicultural relationships. Students developed a multicultural understanding and positive self-concepts.

Cifuentes and Murphy (2000b) discuss the use of videoconferencing to connect four, fourth-grade classes, two in Mexico and two in the United States. The objective of the year-long program was to develop the students' multicultural understanding—an outcome for which the authors provide a rare definition: “*Multicultural understanding* is the appreciation of both similarities and differences along with beliefs, experiences, values, and behaviors across distinct and identifiable cultures within and across groups and societies” (p. 300). Throughout their school year, the students engaged in several activities that culminated in five videoconferences. Primarily, the students created artistic representations of their and their partners' countries, and shared and interpreted these during the videoconferences. The authors provide evidence that the students learned about and gained insight into each other's cultures. These outcomes are more modest than the goals of the program, which included helping students to become socially active citizens, critically thinking members of society, participating members of a democracy, respecters of others, and learners who focus on the process of learning rather than on acquiring specific information.

Gage, Nickson, and Beardon (2002) evaluated the use of videoconferencing in the study of mathematics by high school students. The technology provided an opportunity for students to collaborate with other classes. Teachers reported that the collaborative activities were valuable, noting that students frequently worked on problems beyond the normal curriculum. Students valued the opportunity to communicate with others in presentations and discussions of mathematics problems.

Gerstein (2000) evaluated the use of videoconferencing by two fourth grade classrooms. Videoconferencing provided a means of cultural exchange for San Franciscan and Taiwanese students. The students participated in a dialogue relating to their cultural backgrounds. Videoconferencing was shown to successfully support classroom collaborations. The study also revealed an increase in the students' knowledge of the subject under study, use of technology, and the cultural background of other students.

Green (1999) evaluated a project that sought to establish a K-12 collaborative learning environment between eleven schools. The research showed that students made substantial gains in English reading proficiency based on the opportunity to interact through a videoconferencing network.

Hung & Tan (2004). The authors present situated learning as a theoretical underpinning for taking students out of the classroom via videoconferencing, and they suggest activities and outcomes that are consistent with this theory. The authors suggest that “bringing the community into the classroom”, through connecting students to scientists, experts, and professionals, enhances their learning. Through telementoring, students learn about collaboration, contextualized reasoning, and the manipulation of tools to solve ill-defined problems.

Kinginger's (1999) study examines the use of videoconferencing to connect American and French language learning classes. The author begins by noting the serious mismatch between language as it is taught and language as it is used in real speech communities, and she identifies this disparity as the value of connecting second language learners with native speakers. Interestingly, Kinginger reports that the value of the one-hour videoconference came after the conference, not within it. The anxiety of communicating with native speakers, in the novel environment, and the drastic difference between the language they were learning and the speech that confronted them, left the students unable to profit from the synchronous event. Afterward, however, both classes analyzed a recording of their conference, and the students refined their concepts of spoken French and English, respectively.

Pachnowski (2002) describes the use of videoconferencing as a tool to prepare for and ultimately replace field trips. She argues that virtual field trips are cost effective and reduce problems such as student transportation, safety, and time limitations. Pachnowski explains how to find a virtual field trip provider, what features to look for, how to prepare a class for the experience, and costs. Bringing videoconferencing technology into schools, she argues, opens up new opportunities for curriculum enrichment, cost savings, and learning benefits.

Shaklee (1998) evaluated changes in children's understanding of science when exposed to remote scientists engaged in scientific activities. Students involved in the activity were in a combined second, third, and fourth-grade classroom. Videoconferences with the scientists were associated with improvements in the students' understanding of science.

The Ward Melville Heritage Organization (WMHO) is a nonprofit organization that preserves historical and environmentally sensitive areas in Long Island, N.Y. Part of their mandate is to provide on-site field trips for local students; however, even this limited audience has a negative impact on the environments they seek to preserve. The article describes the WMHO's use of videoconferencing to offer similar experiences to a wider audience with less environment impact. The program was targeted to fourth through ninth grade students. Evaluations indicate that teachers and students enjoy the virtual field trips and find the subject matter engaging.

Thurston (2004) investigated the use of videoconferencing to support international collaborative projects among primary school classes. The goal of the project was to promote multicultural education and awareness. Students in Scotland and the United States delivered presentations to each other from their respective sites. Thurston reports that the students' use of language to define ethnicity became more complex and their attitudes toward ethnic minorities became more inclusive.

## INTERACTIVE LEARNING PROCESSES

Videoconferencing is often incorporated into educational environments because it affords rich interaction between participants. Wagner (1994), however, cautions users to distinguish between characteristics of the medium, which she calls *interactivity*, and the processes that learners actually engage in, which she calls *interaction*. Wagner encourages researchers to document and describe learner interaction rather than assume they are using interactive, real-time

communication media to their full potential.

Distance educators have developed sophisticated taxonomies for characterizing and understanding mediated interaction. Moore (Moore & Kearsley 2004) for instance, distinguishes between learner-content, learner-teacher, and learner-learner interaction. Each form is represented in the K-12 videoconferencing research. Geelan (2004) provides a first person account of learner-teacher interaction using an electronic whiteboard. Gage, Nickson, and Beardon (2002) describe a successful form of learner-learner interaction in which students interact with others from another school. Burke, Beach, and Isman (1997) describe a variant of this in which students interact with experts outside the school.

### INTERACTIVE LEARNING PROCESSES

Burke, Beach and Isman (1997) report on a project in which videoconferencing was used to support collaboration between four teachers' and their students. Teachers initially used the technology to expand their communication possibilities and to access consultants and specialists. Students used videoconferencing to interact with each other. Burke et al. (1997) report that a community of learning developed during the project.

Gage, Nickson, and Beardon (2002) evaluated the use of videoconferencing for the study of mathematics in primary and secondary schools. After completing a preparatory task, students from two schools shared their ideas with each other. On their evaluation questionnaires, the students indicated that they enjoyed the variety, the opportunity to give presentations to others, and the opportunity to discuss mathematics.

Geelan (2004) reports on his experience of teaching a class of 16 students located in four remote high schools. A shared electronic whiteboard allowed Geelan and his students to draw diagrams together and solve problems interactively.

Hearnshaw (1998) evaluated an eight-week course delivered by videoconference. The author concluded that the academic content should determine the optimal mode of delivery. Videoconferencing is considered to be beneficial to support dialogue. Videoconferencing may not be optimal for independent learning focused primarily on content delivery.

### SPECIAL POPULATIONS

Videoconferencing allows the learning context to be projected beyond the physical classrooms; therefore, it can meet the needs of students who have been displaced from their normal school context.

The Ontario based Pebbles (Weiss, Whiteley, Treviranus, & Fels, 2001) program has demonstrated the value of using specially designed videoconferencing hardware to facilitate participation by hospitalized students with their regular class. The authors demonstrate that the

program has benefits not only on the achievement of the displaced students, but also on their counterparts in the classroom, teachers, and hospital personnel.

In addition, students in special classrooms often have greater challenges in extending their interactions to the world outside their classrooms. The Scottish Council for Educational Technology (1999) has worked with handicapped students and concludes, "Videoconferencing was seen as a way of minimizing the social effects of physical disability – of letting them see the world, and of letting the world see them."(p. 14)

Visually-enhanced distance education can be particularly useful for deaf and hard of hearing students. It supports signing language communication, the transmission of audio conversations, and text messaging. With high quality videoconferencing, students and teachers can communicate directly through signing and lip reading (Texas School for the Deaf, 2004).

The capacity of high speed networks such as Alberta Supernet has increased the capacity for a broad range of telehealth services including educational applications (Jennett, 2003). Although we could find little evidence of actual use in schools, the capacity for remote diagnosis, collaboration between local educators and remote experts, and the enhanced sharing of medical and educational records facilitated by these networks increases the capacity for more effective distributed services to special needs students. Young and Ireson (2003) found evidence for the cost effective treatment of a wide range of acute student health concerns using Telehealth services in schools that were delivered to all students.

As expected, the literature reveals that programming for special populations is expensive and time-consuming. A participant in Thorpe's (1998) study notes, "It's getting time to plan it – you need to know about the people involved on both sides – you need really to put a programme together with a specific child in mind and prepare them for it which is something we tend not to have time for" (p. 403). In addition, the videoconferencing hardware must often be redesigned for the unique requirements of special needs students, including a focus on multiple and specialized input devices and an emphasis on portability. Despite these challenges, in a context in which 'no child is left behind', videoconferencing provides considerable affordance to enhance educational diagnosis, support, and service to learners with special needs.

#### SPECIAL POPULATIONS

Gilham & Moody (2001) discuss the use of rudimentary videoconferencing systems to assist youth re-enter their schools and communities after periods of incarceration. Using desktop videoconferencing, community members, correctional personnel, and teachers work with incarcerated youth to assess their academic, vocational performance and needs. The authors characterize the process as convenient, affordable, and successful.

Thorpe (1998) reports on a research study that linked three Welsh secondary schools. The children (all of whom were diagnosed as special needs students) participated in weekly multi-point videoconferences. The main goal was to improve students' social skills through communication with peers. The research found that social and communication skills were developed, technology motivated the students, self-esteem was enhanced, and the technology

provided a structure that helped some students to focus.

The Scottish Council for Educational Technology (SCET) (1999) reports on issues and outcomes associated with special needs students receiving instruction via videoconference. They present series of case studies are presented as practical examples of successes and difficulties in using the technology. The report highlights the potential liberating benefits for students with special educational needs and their teachers.

## KEYS TO SUCCESS

Videoconferencing has been used in numerous educational contexts to date. Although each context is unique, a number of *best practices* consistently arise. Most of these factors are consistent with the literature on effective use and adoption of any technology in educational contexts (Romiszowski, 2004). The most salient features include:

- The importance of training and support for teachers and other school based personnel
- Establishing leadership and a vision that promises significant advantage for all participants
- Liberal access to the videoconferencing technology
- Simplicity of operation
- A clear understanding of costs and learning effectiveness
- The need to engage learners through effective interaction between and among students and teachers
- The development of instructional designs and learning activities that are congenial to videoconferencing and to particular teachers styles (e.g., inquiry based, constructivist, instructional system design etc.)
- The capacity to synchronize class schedules, school timetables, and curricular goals across participating sites
- The need to develop and implement a variety of behavioural management and etiquette expectations, many of which are generic to all classroom teaching but some of which are unique to videoconferencing (see for example <http://www.d261.k12.id.us/VCing/classroom/behavior.htm>)

The World Wide Web provides tools to allow teachers to share their best practices. Besides the new Videoconference Alberta web site ([www.vcalberta.ca](http://www.vcalberta.ca)), other information portals documenting best practices provide a wealth of documentation on all components of educational videoconferencing. The American Videoconferencing in Education web site is a 'Digital handbook for teachers and students and is especially strong on guidelines for good pedagogical

practice (see <http://www.d261.k12.id.us/VCing/index.htm>). The Videoconference Cookbook is a more generic videoconference resource but does have a special section designed for K12 teachers (<http://www.videnet.gatech.edu/cookbook>). Individuals who have used the educational technology share their lessons learned and barriers encountered. Other useful sights include Digital Bridges: A Teacher's Guide to Videoconferencing (<http://www.netc.org/digitalbridges/teachersguide/vdeoconferencing.html>), the Knowledge Network (<http://www.kn.pacbell.com/wired/vidconf/links.html>), and the Northwest Regional Educational Technology Consortium's K-12 Videoconferencing web site <http://neirtec.terc.edu/k12vc/resources/research.cfm>.

## KEYS TO SUCCESS

Barfurth (2002) evaluated the LearnCanada project and the perspective of teachers on the use of broadband videoconferencing for professional development. The teachers were overwhelmingly supportive of the use of the technology for professional development purposes. Success requires countering issues such as time, money, and scheduling which are seen as barriers inhibiting the widespread use of videoconferencing.

Geelan and Fiege (2004) discuss a professional development program that sought to develop the skills and knowledge needed to effectively teach in a virtual presence learning environment. Online communications were continually available to teachers. This professional development concept and online delivery was deemed successful.

Hayden (1999) focuses on the impact of videoconferencing sessions to support constructivist applications and learning experiences. Twenty desirable characteristics of videoconferencing that support constructivist learning environments were identified.

The British Educational Communication and Technology Association (2002) evaluated the use of videoconferencing in five rural primary schools. The authors identify important factors for success, including: a champion to lead the project, pedagogical and technical training, and the opportunity for participants to engage in collegial dialogue.

Pemberton, Cereijo, Tyler-Wood & Rademacher (2004) discuss a common barrier to success that others are reluctant to raise. Firewalls - the hardware or software systems that control access to a districts' network - do not discriminate predictably between authorized and authorized users. Attempts to establish a videoconference connection with sites outside the school or division often require the good will, patience, and cooperation of network administrators who possess these qualities in various amounts.

Varnhagen and Fuchs (2004) offer recommendations of the viability and sustainability of videoconferencing in a rural and remote Canadian school district. The authors suggest that a project champion be assigned to coordinate and lead the learning activities. They also recommended a needs assessment be conducted to determine the community's learning needs. Finally, the authors recommend an integrated approach to videoconferencing with participation by all of the school jurisdictions using the distance learning system.

Wells (2001) examined the concerns of individuals responsible for implementing new curricular requirements for instructional technology. The study concluded that there is a need for balance. There are perceived positive aspects of distance systems (service and teaching) and also perceived negative aspects of distance systems (teaching changes and impersonal environment).

Wideman (2004) evaluated a large-scale federally-funded Canadian videoconferencing project. The project sought to improve student success and transform teacher professional practice through the use of broadband technology in Canadian schools. Teachers from two provinces were provided access to videoconferencing hardware, software applications, and technical and pedagogical support to facilitate participation in the project. Teachers reported increased skill level related to the technology, as well as changes in pedagogical orientation and practice. Students reported that the experience was positive. Students were attentive to the curriculum and showed increased capacity and interest in creating quality learning artifacts. A key to success was believed to be the cohesiveness of the network, both human and technological. As a result of these factors, videoconferencing projects were seen to have significantly better outcomes than traditional enhancement projects.

## EQUIPMENT (HARDWARE AND SOFTWARE)

Videoconferencing requires special technical consideration due in large part to the synchronous nature of the activity – failure of synchronous equipment including audio and video is not tolerated by participants who are left with few fall back alternatives. Network failure, slowdowns, equipment incompatibility and excessive complexity have plagued videoconferencing as compared to less technologically sophisticated delivery systems. In addition, hardware standards, protocols, and equipment have been in a continuous state of rapid change since videoconferencing was first used in schools. However, costs have been decreasing, hardware standards (notably H.323) are being adopted, and reliability and easy to use equipment have been increasing significantly.

Much of the earlier educational videoconferencing literature was based on Integrated Services Digital Network (ISDN) systems. These systems are more expensive to operate than current IP based systems, but until recently were more reliable. The advent of high speed, high bandwidth fiber optic networks allow for more cost effective videoconferencing than earlier systems and offer potential for higher quality video, audio and text transmission than earlier systems.

There are a large number of hardware and software options available to support videoconferencing, and few unbiased comparative studies conducted in authentic educational contexts. Standalone systems, commonly referred to as *set top boxes*, are the most expensive choice. They offer enhanced service and can support multiple large screens; thus, they are usually the first choice for classroom based delivery. However, advances in hardware based desktop systems and software based systems running on high performance machines and high bandwidth networks may also provide a satisfactory, low cost videoconferencing alternative for some educational applications.

Of critical importance is audio quality. Participants may tolerate poor video, but the loss of audio

effectively ends a videoconference (Motamedi, 2001; Robyler, Edwards, & Havriluk, 1997). For this reason, room design and a choice of quality systems that include echo cancellation are critical for successful educational videoconferencing.

Increased capacity in data transmission is important for videoconferencing, especially when multiple sites are linked. However, it has been shown that increasing the quality of the video channel does not necessarily result in measurable increases in the quality of the dialogue or learning outcomes. As in many other applications of educational technology, other factors such as instructional design and learning activities, have a more of a pronounced effect on outcomes than any particular attribute of the medium used to support the instruction (Clark, 2000).

Hardware and software solutions that automatically record videoconferencing sessions and provide them in streaming video format for later viewing offer important asynchronous advantages. This recording capacity can be useful for students who miss classes, student and teacher assessment, and for research purposes. Such recording features are commonly provided in IP based audiographic systems, but are, as yet, not standard features of videoconferencing systems. We anticipate developments in this area and are encouraged by the early work done at the University of Alberta (Boora et al, 2003).

#### EQUIPMENT: HARDWARE, SOFTWARE

Boora, Davis and Montgomerie (2003.) participated in the use of videoconferencing in a rural and remote Canadian school district pilot project. The pilot project implemented various educational technologies in high school classes. The technologies included real-time videoconferencing, interactive whiteboards, individual computers equipped with workgroup software, and provision of asynchronous access. Synchronous communications were recorded with access to these learning resources also available through asynchronous means.

Donegan (2002) evaluated the cost effectiveness of videoconferencing and online software sharing. Videoconferencing was used to provide support, assessment and training to professionals. The ACE Centre's experience of using low-cost videoconferencing and online software sharing was very positive.

Hearnshaw (2000) evaluated the impact of higher levels of image quality on the effectiveness content delivery. The author showed that increasing the quality of the video channel did not have a measurable increase in the quality of dialogue. Therefore, where bandwidth is limited with resultant lower quality images, the impact on learning is not necessarily detrimental.

Montgomerie, Davenport and King (n.d.) examined two uses of broadband networks and broadcast quality video. An evaluation on the use of full motion video by students is provided. The use of videoconferencing in a rural and remote Canadian school district pilot project builds on this initial study. The authors conclude that full motion video environments in K-12 systems can address social and economic needs of educational institutions.

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