Video-conferencing Research Community of Practice Research Report

Alberta EDUCATION

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Foreword

This research report is a result of the work done by a research team comprised of members from Athabasca University, University of Lethbridge, and the Galileo Educational Network Association, and has been edited for the target audience. It forms part of a larger project that developed a community of practice in which teachers, students, researchers, and school jurisdictions in the province of Alberta came together with a common sense of purpose to learn how video-conferencing can be used effectively within K-12 education. A hypertext version of this document will be posted on VCAlberta.ca that will allow readers to link directly to the areas that are of most interest to them and to access related videoclips.

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Fort Vermilion School Division
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Edmonton Public Schools
Prairie Rose School Division

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Section 1: Executive Summary

Context and Purpose

Video-conferencing technology and other networked-enabled information and communications technologies have potential to enhance and improve education practice and systems in very significant ways. Video-conferencing creates a real time connection between participants located anywhere on the Internet. When operating at its highest capacity, this connection supports body language interaction, shared display of real time events, full motion kinesthetic activity, and quality audio interaction. These media characteristics can enable high levels of immediacy between participants, enhancing learning and facilitating productive collaborative discussion and decision-making.

Video-conferencing is an example of an advanced technology application that has the potential to link remote sites together and offer new ways for the delivery of learning, professional development, and administrative programs and services. The implementation of Alberta SuperNet, the provincial high-speed network, makes video-conferencing a feasible option for K-12 jurisdictions that were previously limited by bandwidth restrictions. Once Alberta SuperNet reaches full connectivity in late 2005, the capacity to use this technology will be made available to every K-12 school, post-secondary institution, health service and government office in the province.

This study took place in 2004-05 during the initial roll out of the Alberta SuperNet. The purpose of the study was to describe early uses of video-conferencing within five Alberta school jurisdictions, and to identify issues and promising practices that could inform future use of video-conferencing technology within K-12 educational contexts.

The study supports Alberta Education's Learning and Technology Framework, which "*focuses on providing direction, support and coordination for the effective use of technology to support learning delivery, knowledge and skill acquisition, learning system management, and research and innovation*" (Alberta Education, 2005, p. 3).

This study was conducted by researchers from Athabasca University, the University of Lethbridge, and the Galileo Educational Network. Alberta Education provided funding and human resource support for both the research study and the larger research community of practice.

Design of the Study

The participatory research method used in this study included a variety of activities focused on developing a research community of practice. In collaboration with staff from Alberta Education, the researchers worked with teachers, administrators, technicians, and support personnel from five Alberta school jurisdictions:

- Fort Vermilion School Division No. 52
- Red Deer Catholic Regional Division No. 39
- Grande Yellowhead Regional Division No. 35
- Edmonton Public Schools
- Prairie Rose School Division No. 8

Research activities included:

- Site visits;
- Interviews with key participants;
- Constructing and administering surveys;
- Facilitating focus groups;
- Participating in online and face-to-face professional development sessions;
- Mentoring to develop inquiry-based pedagogies;
- Videotaping instructional events;
- Constructing and supporting a virtual community website;
- Producing associated research videos; and,
- Producing a comprehensive research report.

The research team worked with teachers, administrators, technicians and staff from Alberta Education to create activities and opportunities to share expertise, develop supportive relationships, and educate each other. These activities included face-to-face events, development and support of an online portal, online training sessions and mentoring of individual teachers.

Summary of Findings

Common Uses of Video-Conferencing

Video-conferencing activities used by the five jurisdictions in this study can be classified into three major types of innovative applications. Video-conferencing is being used to:

1) Enhance and expand administration services and professional development activities for staff;

2) Enhance student learning in regular classrooms through the use of collaborations with other remotely distributed students, community experts, and distributed learning resources; and,

3) Deliver courses by distance education to small and remote schools where full programming options are often reduced because of small class sizes and/or shortage of specialty teachers.

Researchers found general satisfaction and evidence that video-conferencing adds significant value to all three activities.

Use of video-conferencing technologies for administration and professional development provides a sound rationale for the purchase and support of video-conferencing technologies in Alberta schools. Researchers concluded that there were significant cost and timesavings associated with administrative and professional development activities that used video-conferencing technology. While work remains to be done on gaining connectivity outside a single jurisdiction, early results indicate value for ongoing consultation, provision of routine and special administrative meetings, delivery of formal and informal professional development opportunities, and access to remote resources for professional development purposes. Lower costs related to travel expenses and timesavings associated with extensive and sometimes dangerous winter travel are compelling reasons to expand the use of this application.

Video-conferencing technology was observed to enhance regular classroom delivery by allowing students to engage in learning activities with peers, experts, and other educational resources outside of their traditional classroom. Students generally enjoyed these enrichment activities and seemed eager to expand their learning opportunities using the technology. The technology also fit with some inquiry-based learning designs and allowed students to interact first hand with experts and remote students with particular skills and interests. These enrichment activities were wide ranging and included linkages with students in other regions of Canada and internationally. In an era marked by pervasive networking, exposing students, educators, and administrators to the skills they need for effective use of these emerging learning and communications technologies not only enhances their performance and motivation, but also empowers them with lifelong learning skills and experiences.

While video-conferencing technology can play an important role in adding immediacy to distance education delivery, when used alone it does not appear to provide as rich an environment as one in which various tools and techniques are blended to create more engaging and effective learning experiences. The research team concluded that video-conferencing technology alone provided only a relatively limited set of interactions, and that it should be enhanced with other networked learning tools, both synchronous and asynchronous, to increase educational efficacy. These tools could include webconferencing, e-mail, blogs, computer-conferencing, use of individualized learning objects, collaborative work project spaces, web searches and e-portfolios.

Lessons from the Research: Promising Practices and Recommendations

The research team created the following list of practices they saw as representing effective use of the video-conferencing environment. These should be considered as "emerging promising practices", since their development in the field is relatively new and such practices are expected to evolve as jurisdictions continue to use the technology for multiple applications.

Promising Practices

1. Professional Development

Change in one component of a system forces change in all other related components. Video-conferencing allows – and in some cases mandates – change in practice and policy. To ensure that such change works to improve learning and cost effectiveness, staff and students should be given the opportunity and incentive to participate in maximizing the benefits and minimizing negative repercussions from this change. Education professional development systems must address the unique needs of both novice and experienced teachers. Hands-on use of video-conferencing technology within and across jurisdictions should be encouraged, so that teachers can increase their skills in teaching in video-conferencing environments.

2. Student Empowerment through Operation with the Technology

Allocating responsibility to students to configure, troubleshoot, produce, and operate the video-conferencing equipment has many advantages, not only for the teachers, but for all participants. The development of Computing Technology Sciences (CTS) modules or locally developed courses in which video-conferencing operation, direction, and production are learning activities, were observed as a means to empower students and equip them with new networking skills.

3. Technical Support

Technical support is a critical factor in successful video-conferencing activities for administrative, distance education, and enrichment activities. The best support observed included capacity for remote diagnosis of video-conferencing equipment, including capacity to monitor all technology and to re-boot and re-configure equipment remotely. There is opportunity for cost effective sharing of this type of technical support through collaboration among school divisions. Best practice includes capacity for emergency backup via redundant video equipment or more cost effectively by audio linkage (as supplied through commercial telecom vendors, or through existing jurisdiction-owned telecommunications switches).

4. Developing New Pedagogies

New tools often create opportunity for changes in practice. Video-conferencing and other networked tools can be very effective in creating constructivist learning scenarios in which students use the tools to create their own solutions to curricular problems. Students were more engaged in active learning when new instructional designs, such as inquiry-based learning, were employed.

5. Enhancing Delivery Capacity

In each of the jurisdictions observed, the demand for video-conferencing classrooms has grown, in some instances beyond the capacity currently available. Some jurisdictions have purchased smaller, desktop video-conferencing units for use in offices, staff rooms, etc., as a cost effective means to increase video-conferencing

capacity. Such systems are very functional for individual and small groups of teacher and students and can easily connect to larger systems.

6. Mentoring to Support a Pedagogy of Inquiry

Video-conferencing technology, along with additional resources such as online communities, subject specific Web sites, and e-mail, are very successful in creating a robust mentoring environment supporting an evolving pedagogy of inquiry. This is significant for the development of effective online communities of practice. Adding video-conferencing to this mix of enabling technologies holds possibilities to supplement or replace face-to-face mentoring.

7. Enhanced Audio

Audio is the most important aspect of any video-conferencing event. Audio quality at each site varied significantly. Desktop area boundary microphones were successful for small groups of students. Ceiling microphones seemed to create problems; however, with too much background noise added to the conference. Lapel or dedicated instructor microphones were most effective for transmitting uninterrupted audio from the teacher. The best audio solution observed included dedicated desk mounted microphones for one to three students, and wireless lapel microphones for teachers.

8. Site Visits by Teachers to Remote Classroom

Teacher visits to remote classrooms have long been used in distance education to support the development of quality student-teacher relationships. Such visits in this study were enjoyed by both teachers and students, and helped reduce the sense of isolation experienced by both. Best practice will likely include teacher visits to remote distance education sites early in the course to help build rapport.

9. Face-to-face Lab Days

Face-to-face labs allow learners in the same class to socialize and collaborate. In addition to teacher visits to remote sites, there is value in gathering all students in a common location. These activities can be used to provide access to labs or other technology, to learning resources not available locally, or to engage in cooperative or collaborative activities. Students noted that when these activities did take place, they were better able and more interested in communicating with other students. Opportunities to meet face-to-face is a strong incentive for student participation in all aspects of the course and program; therefore, face-to-face class meetings are a component of quality courses.

10. Central Coordination

Video-conferencing, by definition and actual practice, is not a single, stand-alone school activity. Thus, video-conferencing is challenging to support in school systems that are becoming more decentralized and focused on school-based decision making and budget allocation. There are numerous issues related to scheduling, school bus coordination, and professional development for teachers, policy development relating to incentives for teachers, programming decisions, and equipment purchases that are

best coordinated or decreed from a centralized office perspective. All school jurisdictions in this study were able to devote at least part-time division level administrative support to their programs and all argued that such support is critical.

11. Incentives
Distance education teaching in a video-conferencing context (especially when multiple sites are involved) requires more preparation than normal classroom teaching. Some school jurisdictions have developed incentives such as course release, equipment allocations, or class aides that encourage teachers to make the extra effort involved. The best incentives are customized to the unique needs of individual teachers and systems, and thus will be different in different contexts.

12. Secure Connectivity Beyond a Single Jurisdiction
Administration, professional development, and enhancement models of video-conferencing all reach maximum effectiveness when connectivity is supported to locations anywhere in the world. Seamless connectivity that spans secure firewalled systems, at present, is not possible in most Alberta schools. Further study and development is needed prior to a standards recommendation from Alberta Education on an appropriate solution to this problem.

13. Continuous Research and Evaluation
This study of early adopters of video-conferencing in five school jurisdictions points to the need for ongoing description and evaluation of video-conferencing applications. The technical and pedagogical context related to video-conferencing is changing rapidly and requires ongoing effort to insure ensure that schools are able to take advantage of developments and best practices as they evolve.

14. Blended Learning for Distance Education
Delivery of complete courses and programs at a distance benefits from an appropriate mixture of synchronous, asynchronous, text, video, and audio delivery to maximize motivation and learning effectiveness. Increasing media mix, however, usually increases costs. Thus, further research is needed to determine optimal mix of video-conferencing with other synchronous and asynchronous technologies.

Research Team Recommendations

Recommendations to Teachers:

- Investigate and develop instructional designs and learning activities that focus on providing space and motivation for students to work individually and collaboratively to create and share their own understandings of learning content using video-conferencing and other information and communications technologies.

- Participate online and whenever possible face-to-face in learning networks to share ideas of successful teaching and to support each other.

- Increase personal competency with video-conferencing and other digital technologies by exploiting the professional development opportunities and self-study provided by the technologies themselves to enhance personal productivity in performing instructional, professional and administrative tasks.

- Integrate other media use into lessons such that learners are able to acquire the skills of searching, personalizing, and manipulating information from many sources to construct their own knowledge.

- Develop blended learning opportunities for students and yourselves whereby face-to-face encounters among participants are blended with video-conferencing and online learning opportunities.

- Develop activities whereby students learn to use and control the video-conferencing technology to co-create their own learning experiences.

Recommendations to District and School level Administrators:

- Provide central coordination, policy development, and support for distance education enrichment and administrative applications of networked technologies, including video-conferencing.

- Provide opportunities for formal training and informal networking among teachers who are using video-conferencing technologies.

- Ensure that technical support is available, in real time, to teachers who are dependent upon communications technology to support active learning in their classes.

- Develop policies so that teachers who participate in distance education programming are supported in the efforts involved in effectively teaching in distributed contexts.

- Develop cost effective ways to provide effective supervision and support for students in remote video-conferencing classrooms. These will likely include designs such as use of teacher aides, on-call support from administrative or other teaching staff, construction of remote video-conferencing rooms with direct observation by school staff, and other strategies to provide assistance to students and the remote teacher in a timely fashion.

- Maximize the capacity of the SuperNet to transmit documents in any medium and to support document exchange between and among students and teachers. Utilize the capacity of available technologies to make this task as seamless and easy as distributing materials in a face-to-face classroom.

- Ensure that accounting procedures are in place to determine the real cost of all instructional programs, especially those that make use of video-conferencing technology.

Recommendations to Technicians:

- To support seamless connection of video-conferencing technology with users around the world, actively follow and participate in efforts to create means whereby local Virtual Private Networks (VPNs) can connect with other SuperNet VPNs, CA*net, and the commercial Internet.

- Provide fallback audio-conferencing capacity for teachers to use when video-conferencing connectivity to any single site or across the network is compromised.

- To ensure that high quality audio connectivity is available to all video-conferencing participants, focus on the quality of the audio in video-conferencing classrooms. This will likely include use of wireless microphones by teachers and multiple, distributed microphones for students.

- Develop and maintain the capacity to remotely diagnose and maintain video-conferencing equipment, including the capability to completely reboot hardware.

- Seek opportunities for professional development and training such as those offered by the Northern Alberta Institute of Technology (NAIT) related to SuperNet and video-conferencing operation and support.

Recommendations to Alberta Education:

- Continue support for the emerging video-conferencing focused community of practice by:
    - Continuing the secondment of educator/leaders from the system to provide province wide coordination, training and support for the video-conferencing community;
    - Continuing support and animation of the online community begun on VCAlberta.ca; and,
    - Continuing support for the development of professional development resources available anytime/ anywhere for new and experienced video-conferencing teachers. These should include:
        - Promising practice guidelines
        - Instructional videos related to both pedagogical and technological training on effective video-conferencing application
        - Community building, support and advice forums
        - Listings of Alberta and global video-conferencing activities and opportunities
        - Technical reviews and announcements of new technologies

        - Results and reviews relevant video-conferencing related research studies.

- Continue to support participative research in which professional researchers, teachers, students, and administrators evaluate and innovate collaboratively, thereby developing the most cost and learning effective educational applications of video-conferencing technologies.

- Support the development of media curricula (i.e., CTS units) such that students are trained in the design and production skills associated with producing video-conferencing enhanced programming.

- Provide support for pilot projects using video-conferencing and other networked technologies, and assess their effect on learning, teaching, and institutional practice and culture.

Recommendations to Students:

- Learn to use the video-conferencing technologies and offer your knowledge to your classes and learning community.

- Imaginatively plan for ways that this environment can be most effectively used to enhance your education.

- Be assertive in remote video-conferencing classrooms to ensure that no one disrupts or deprives you of your learning opportunities.

Section 2: Background Information and Project Description

Over the 2004-05 school year, researchers, teachers and administrators from Alberta's secondary and post-secondary institutions collaborated to form a research community of practice focused on the use of IP-based video-conferencing. It is from within this research community of practice that many of the findings in this report have been documented and discussed. To ensure that the school jurisdictions and other stakeholders provided the necessary information for validity and accuracy of information, iterative feedback was used for the development of this report. This approach put researchers in a unique position to communicate with the jurisdictions and other stakeholders on fundamental aspects of research and community building. This study focused on five activities found to be essential for video-conferencing research community building:

- conducting formative research on the jurisdictions' use of video-conferencing;
- mentoring individual teachers on innovative inquiry-based teaching philosophy and practice;
- stimulating professional development activity in face-to-face meetings, online via a web portal, and in distributed video-conferencing activity;
- creating videographies of the project; and,
- documenting activities and issues in the jurisdictions, and highlighting those observed to be emerging promising practices.

A significant contextual factor that influenced this study was the delay in the rollout of the Alberta SuperNet. This high-speed network was scheduled to be operational in all participating schools before the start of this study. Significant delays in the SuperNet's construction, however, resulted in none of the school jurisdictions in this study receiving full access to the complete provincial network prior to the end of the project. Three of the five jurisdictions were able to function within their division using "early SuperNet islands," and a fourth used CA*net 4 connectivity installed during a previous trial. The fifth jurisdiction had high bandwidth connectivity only during the final three months of this study. These delays, in varying degrees, inhibited – and in one case precluded – effective participation with the video-conferencing application as planned. Nonetheless, the research project continued and now serves as prospective study of this technological intervention, rather than the retrospective study originally planned. Additional research on Prairie Rose School Divivion's applications of video-conferencing technology over SuperNet is planned for the 2005-06 school year.

The research team engaged by Alberta Education for this evaluation project consisted of educational technologists, teachers, researchers, technicians, and multimedia producers from Athabasca University, University of Lethbridge (U of L), and Galileo Educational Network Assocation (GENA). The participatory research design used has been referred to as a *responsive* approach to the case study design. This approach lies somewhere

between traditional approaches where researchers descend upon a situation and carry out a pre-ordinate investigation versus alternative forms such as action research, which often make onerous demands on the time and energy of practitioners and unrealistic assumptions about their theoretical pursuits. Characteristic of responsive evaluation, participants from each of the five sites were involved in each step of data collection and analysis. Stakeholders such as teachers, technical support personnel, policy makers, and others were instrumental in identifying aspects of practice that warrant description. As active participants, they also assessed the provisional descriptions, and determined the criteria upon which this project was evaluated. The descriptive tasks (e.g., developing instruments, making observations, composing reports), however, were carried out by the researchers. This participatory approach to research distributes expertise and resources effectively by initiating a conversation between personnel at different sites, and between site personnel and the researchers.

The participatory research design involves developing research questions in consultation with the participants. At the beginning of the project, researchers developed an initial contour of the five case studies based on preliminary discussions with various stakeholders from the five school jurisdictions, a review of evaluation reports from some of these sites, and a review of the goals for this project established by Alberta Education.

At all five sites, stakeholders engaged in parallel conversations around the following descriptive and evaluative questions:

- How can the larger setting of the school jurisdiction be characterized as well as the particular context in which broadband video-conferencing is being implemented?

- What are the guiding purposes and specific goals of your broadband video-conferencing projects? How can progress toward these goals be determined?

- Which pedagogical models guide your conceptualization of broadband video-conferencing activities?

- What specific activities is broadband video-conferencing used to support? What types of information reveal the merit of these activities?

- What networked technologies and facilities do you use?

- What funding models are used to sustain enrichment, distance education and professional development (PD) activities?

- How are face-to-face classroom and asynchronous networked-based learning activities integrated with video-conferencing in your programs?

- What types of technical support do you require prior to and during implementation? How do you determine whether the support is adequate?

- What types of PD activities accompany your implementation? How do you evaluate the effectiveness of these activities?

- What is the role of change agents, upper management support, and other factors identified in the literature with adoption of innovations?

- What are the successes and limitations of the projects, activities, existing technologies, facilities, and PD activities?

- What promising practices do you recommend for beginning school jurisdictions?

To provide answers to these and other emerging questions, researchers engaged in a series of evaluative, participatory and research focused activities:

- Initial review of the research literature on K-12 Internet-based video-conferencing (For a complete literature review, visit: vcalberta.ca/community/litreview.pdf);

- Site visits to introduce and familiarize researchers with the context of each of the five cases;

- Development of survey instruments and interview questions;

- Second site visits to videotape classes and interview participants;

- Participation in three face-to-face research community events with participants from all five jurisdictions to share insights and build consensus on major issues to be investigated;

- Development of a web portal (www.vcalberta.ca) containing a provincial directory of video-conferencing facilities, resources for effective practice using video-conferencing, and community participation tools;

- A third site visit to present and confirm initial findings;

- Production of four videographies documenting the use of video-conferencing in the cases;

- Mentoring teacher volunteers on use of inquiry-based instructional design processes supplemented by video-conferencing;

- Facilitation of PD events delivered via distributed technologies (video-conferencing and webconferencing); and,

- Administration of online survey to triangulate findings.

The report distinguishes between three different types of video-conferencing use:

1. Video-conferencing as a communication tool for administration and professional development activities;

2. Video-conferencing as a means to enhance educational value of regular classroom instruction by engaging students with external experts, peers, or other resources; and,

3. Video-conferencing as a synchronous communication tool for delivery of distance education courses.

Setting the Alberta Context

This project took place in five school jurisdictions in the Province of Alberta, Canada. Jurisdictions were selected based on their early experiences and unique applications of video-conferencing technology. The research provides insight into unique applications and purposes for video-conferencing, and illustrates how the technology can be adapted to meet the locally defined needs of individual learners, teachers, and administrative systems.

Alberta has a long tradition using innovative educational technologies for distance education. Since 1923, the Alberta Correspondence School, and later other school jurisdictions, have been delivering K-12 educational programming using a variety of technologies including: print-based correspondence, radio and television, telephone and audiographics, and most recently web-based technologies (Haughey & Muirhead, 1999). There has not been wide spread use of ISDN-based school year or two-way interactive television, thus the move to IP-based video-conferencing was observed to be a novel experience for these five jurisdictions.

The second critical contextual influence was the Alberta government's decision in 2000 to build the SuperNet, a high-speed digital network linking 426 urban and rural communities throughout the province. The goal of this CDN $292 million project was to provide high-speed connectivity for Alberta's public sector institutions including schools, libraries, health facilities, and government offices. Construction on the SuperNet began in 2002 and a completion date is expected in late 2005. At the time of the research study, Alberta's schools ranged in connectivity levels.

Several studies show that educational institutions are expected to become one of the major users of the SuperNet, and that video-conferencing is perceived by distance educators as the most compelling application for this new network (Poscente, Rourke & Anderson, 2005). The imminent arrival of a network that provides 5-10 megabit per second (Mbps) connectivity at no cost to local school jurisdictions has provoked discussion among parents, teachers, and administrators who seek to understand how the technology can be most advantageously applied. The most common application anticipated by rural school jurisdictions is the capacity to provide a full complement of

courses at each of their school sites – even when student numbers do not justify employment of a specialist teacher. Others see the technology as a high-bandwidth delivery vehicle to provide course enhancements to enrich student learning experiences. Regional administrative bodies and inter-jurisdictional collaborations anticipate use of the technology to facilitate PD and other administrative activities.

For the school jurisdictions yet to be connected to the SuperNet, other solutions have been put in place to provide some connectivity. Some school jurisdictions have been using high-speed networks through combinations of existing government networks such as Alberta Government Network (AGNpac) and/or local cable or telephone companies. Nonetheless, many schools are anticipating accelerated technological change once they are fully connected to the SuperNet and the networking opportunities it affords.

In addition to funding the creation and ongoing costs of the SuperNet for Alberta's schools, Alberta Education has been involved in initiatives designed to prepare schools to use this resource effectively. These initiatives include:

- **Dedicating staff to liaise between schools and those implementing and building the SuperNet.** These people make presentations and provide training sessions for teachers and administrators.

- **Purchase of a 70 port multi-point control unit (MCU).** This technology allows up to 70 sites to be joined simultaneously. It was purchased for internal department use as well as for external bookings by school jurisdictions.

- **Development and deployment of SuperNet technical training.** Alberta Education contracted NAIT for the development and delivery of a series of courses designed to help technicians install and operate the SuperNet in their local school jurisdictions. A description and schedule of courses is available at http://www.nait.ca/supernet/.

- **Establishing Video-conferencing standards.** The Technology Standards and Solutions Program Office of Alberta Education has adopted the H.323 standard as the compression algorithm for video-conferencing. This decision helps school jurisdictions choose compatible video-conferencing technology that enhances connectivity.

Research Limitations

Researchers did not observe all of the video-conferencing events that took place in the participating jurisdictions, nor did they select a mathematically random sample of events. As well, the presence of the researchers at the sites influenced participants' behavior. The research includes descriptions of the events attended, and reports of what the participants chose to relate on those days. Therefore, results are not generalizable to all K-12 video-conferencing events everywhere.

Nonetheless, researchers took steps to ensure that their claims are trustworthy, credible, dependable, and transferable. They made multiple visits to each site, talked at length with several key stakeholders, and encouraged the participants to direct the study's focus and to guide data collection and analysis. During the analysis, researchers engaged in lengthy discussions with other professionals who have experienced and studied video-conferencing use in K-12 settings. They have catalogued all of their data and it is open to inspection (with due consideration to the protection of human participants in research).

Participant Characteristics

Students enrolled in video-conferencing delivered courses for several reasons. When school jurisdictions offered core courses through video-conferencing, students took them because they needed the courses for their diploma, to flesh out their timetables, or obtain a sufficient number of credits to graduate. "*We're not allowed to have spares*," one student explained, "*but my schedule* [varies], *so I put the video-conference course in there to fill the spare. Plus, it will give me five credits.*" When jurisdictions offered optional courses, students typically enrolled out of their natural interest in the content, and as space in their daily schedule allowed.

Students stated that they enrolled in video-conferencing courses because that was the only delivery option available, or they wanted to obtain instruction from a specialized teacher. Sometimes an equivalent course was available via correspondence study, but this format was consistently regarded as a last resort. "*There have been requests for our* [optional] *course from students at other schools*," reported one teacher, "*but we've never been able to accommodate them for one reason or another, either because students didn't have a teacher who was prepared to teach it, or because students couldn't fit it into their timetable. Video-conferencing gives us an opportunity to accommodate those requests without having to hire a new teacher, or lose a math course, or something along those lines.*"

Students talked about the range of their experiences with alternate modes of education; most had taken at least one course through correspondence, audio conferencing, or video-conferencing. Three of the jurisdictions in this study had established video-conferencing programs, and many of their students had taken courses in the video-conferencing format. All jurisdictions had access to the Alberta Distance Learning School's correspondence courses, so it was rare to interview a group in which no one had taken one or two courses via correspondence.

All teachers involved were participating in their first video-conferencing experience. One had requested the opportunity to experience a new mode of teaching, but most had been persuaded by their administrators to fulfill a need in the jurisdiction. When asked how s/he came to be teaching via video-conferencing, one teacher said: "*I was thrown into it. I don't really know how they made the decision. The teacher that was here before me went on paternity leave, and he was the only* [subject specialist] *in the school. I was originally hired because of my expertise in the same subject, so I ended up teaching it by default, I think. There's really no other explanation.*"

The amount and type of preparation teachers received before their first experience varied, though none thought that it was enough. Some teachers revealed they had no preparation at all. "*When August 26th came and classes started, I was trying to figure out the password and the username to log on. It was quite a zoo*," said one teacher. Others were supposed to receive some training, but it fell through: "*We were actually supposed to have a training session the day before all the teachers came back, but the equipment didn't work so we didn't get any work done that afternoon. We were supposed to talk to some of the teachers who taught with video-conferencing last year, and we were supposed to go through what worked and try a lesson. But nothing was working.*"

Two teachers received more preparation. The first teacher described a combination of technological and pedagogical training: "*We came in one afternoon and got to use the remote to see how it worked. We received some advice about handling classroom management issues and about not ignoring the class on the wall and that sort of thing. There wasn't a lot. We might have been there for about an hour. A lot of that was just practicing with the technology.*"

Among the teachers interviewed, the one who received the most training described her preparation as meager: "*Our technology coordinator took me to observe a lesson last year, and we talked about it, and the coordinator showed me how to use the various things very briefly. When I began this year, our technical guy came in everyday for about a week and a half at the beginning of every lesson. He made sure I was okay getting things up and running and how to use things and stuff. Before I started the course, he showed me how to use everything. He also created a document with step-by-step instruction on how to operate the equipment, and I've got it to refer back to. Had he not been there, I'd have had a nervous breakdown.*"

This teacher distinguished this from the pedagogical preparation, which she described later: "*I attended a session at the University of Alberta that was organized by a group of educators from various jurisdictions that were using video-conferencing. They talked about how you teach this way, and they said it's the same way you teach in the regular classroom: You adapt for your learners, you adapt for your situation, and if something goes wrong, you figure out how to deal with it. That was one afternoon.* (laughs.) *It was definitely better than nothing. The attendance at the afternoon session told me that if I can adapt to a regular classroom, I can probably adapt in this format. I knew after listening to that I would be able to handle it. I don't know that I would have been at all prepared had I not attended that session.*"

As can be observed from these quotes, the administration and delivery of PD to enable teachers to use new technologies effectively remains problematic. By definition, schools offering and receiving distance education programming by video-conferencing are remote from each other, and the challenges of effectively training and supporting these teachers are substantial. This was not the first semester for video-conferencing delivery for any of these three jurisdictions; thus the experiences of these second-wave teachers may be different from those who taught during the first year of delivery. Researchers felt

the insufficient opportunities for PD and training speaks to the need for jurisdictions to plan ongoing PD aimed to help teachers new to video-conferencing, as well as more advanced PD for experienced teachers.

Secondly, video-conferencing is rarely perceived by students or teachers as a first choice of education delivery. Rather, like other distance education methods, video-conferencing is perceived to be as less than perfect, but much better than other alternatives.

Finally, it is interesting to note the paradoxical nature of teaching in a video-conferencing environment. This mode of delivery is considered by some to being similar to traditional classrooms, and viewed positively by those who gauge teaching effectiveness through analyzing similarities in the video-conferencing classroom and the traditional classroom (Simonson, Schlosser, & Hanson, 1999). Indeed, many of the issues faced by classroom teachers are also apparent in the video-conferencing context.

The Media Shapes the Message

Researchers observed the video-conferencing context to be fundamentally different from face-to-face classrooms. *The media affects and determines the message.* Logistical issues related to dissemination of material across multiple sites, presentation styles using new devices, the ability of the teachers and students to read and respond to body language, comfort and acclimatization to new environment, and quality of voice, video, and graphic representation, are all disrupted by video-conferencing technology. Compared to traditional classroom delivery, many of these attributes and qualities are either enhanced or adversely affected in the video-conferencing classroom. This creates a whole new framework for teachers to adjust to both psychologically and pedagogically. These challenges can be overcome, however. Moreover, the advantages of video-conferencing technology can be exploited. Nonetheless, it would be a disservice to describe video-conferencing as being the "same as" or "very similar" to classroom delivery. The real-time interactive capability of video-conferencing technology makes it the most similar of the distance education technologies to the real classroom – but it is still not the same.

Inquiry Mentorship Studies

Within the context of this study, the role of GENA focused on providing professional development to teachers in inquiry-based teaching and learning. GENA consultants provided one-to-one mentorship to three high school teachers who volunteered to participate in this part of the research project. Each teacher was teaching a Grade 12 diploma examination subject. The teachers worked collaboratively with GENA mentors to design inquiry work for students. This mentoring was conducted at a distance using a variety of technologies:

- Video-conferencing
- A web-based collaborative environment for teacher planning
- Telephone

- E-mail
- Webconferencing software.

Together, teachers and mentors:

- Reviewed government mandated curriculum guides at the beginning of the design work. In part, this helped teachers distinguish between mandated objectives and approaches to the curriculum suggested by resources such as textbooks.

- Discussed and identified 'what matters' most about the topic that the teacher had selected as a topic living in the world, not just as a unit to be covered. Mentoring helped teachers articulate the fundamental understanding(s) they wanted students to gain from an inquiry into this topic. They were encouraged to explore the importance of the topic in terms of today's world. Why should students become committed to these ideas, issues, problems or debates that form the basis of the mandated curriculum topics?

- Planned and implemented relevant, intellectually robust, authentic tasks or problems. Mentors helped teachers:
    - develop their inquiries;
    - explore alternative approaches to the topics; and,
    - work with students.

Specific descriptions of the three mentoring projects are detailed in the individual case studies of the participating jurisdictions.

Section 3: Case Studies

Five Case Studies: Early Use of IP-based Video-conferencing

An in-depth look at each of the five participating school jurisdictions allows for a better understanding of how early adopters are implementing video-conferencing in the K-12 environment.

The discussion to follow is framed around the following topics for each of the five Alberta school jurisdictions: demographics, setting the stage for video-conferencing, trajectory, equipment and technology, applications, outcomes, keys to success, plans for the future, and where applicable, inquiry mentorship study.

The description begins in the Fort Vermilion School Division No.52 (FVSD), and moves through the Red Deer Catholic Regional Division No.39 (RDCRD), the Grande Yellowhead Regional Division No. 35 (GYRD), Edmonton Public Schools (EPS), and ends in the Prairie Rose School Division No.8 (PRSD).

Fort Vermilion School Division No. 52

The compelling application and interest in video-conferencing for FVSD is the provision of quality educational programming for its sparsely distributed student population.

Operations are conducted in a central office in the town of Fort Vermilion, where most video-conferencing administration takes place. This site has a video-conferencing suite that is used for administrative meetings and linking to other schools within the division. Most video-conferencing scheduling, coordination, and technical support is housed in the Fort Vermilion, and these services are distributed from there to specific schools.

FVSD encompasses 12% of Alberta's landmass, but with only 16,000 people, it accounts for less than 1% of Alberta's population. The division is geographically situated just south of the Northwest Territories border, and is an eight-hour drive north of Alberta's capital city, Edmonton. There are 15 schools in the division, with some located up to 285 kilometres apart. Throughout its 15 schools, FVSD serves 3,800 students (Montgomerie, King, Dropko, 2003). FVSD has five high schools involved in their Grades 10 to12 video-conferencing project: La Crete Public School, Fort Vermilion Public School, Rocky Lane School, High Level Public School, and Rainbow Lake School. FVSD may potentially expand video-conferencing to the Meander River area in future years. FVSD is in their third year using video-conferencing, and have focused on its use as a tool for full courses, distance education delivery.

Setting the Stage for Video-conferencing

Rural Advanced Community of Learners (RACOL) was an earlier collaborative research initiative involving FVSD, the University of Alberta (U of A), the University of Calgary

(U of C), the Banff Centre, NAIT, the Netera Alliance, and Sonic Design Interactive Inc. While the RACOL project used MPEG-2 as the main protocol for video communications, the infrastructure is capable of converting MPEG-2 to other existing video protocols, including H.323, to allow for cross-jurisdiction video-conferencing. This project has been in production on SuperNet since September 2, 2003 and currently connects five learning sites.

FVSD anticipated a shortage of qualified teachers especially in the specialist areas such as languages, senior high mathematics, and science. This remote jurisdiction has experienced difficulty in recruiting teachers and often looks outside the province to hire. With the video-conferencing classrooms, built under RACOL, the thinking was that a teacher who is not a resident of the community could provide instruction in these areas.

The project aimed to explore the potential of broadband networks and digital technologies to create a video-conferencing classroom that put students and teachers who are located at great distances from each other together in a common, real-time learning environment. Grade 11 and 12 courses including mathematics, physics, and aboriginal studies were delivered. A project between GYRD and FVSD to link their school year system together to deliver French 13 was piloted, with a teacher in GYRD to instruct a class in FVSD.

Trajectory

FVSD's current goal for their video-conferencing system is to offer students a full curriculum through an interactive, high-resolution video-conferencing environment. Video-conferencing courses in FVSD are established based on need and committed to a three-year 'evergreening' cycle. Students are aware of the courses offered and can use this information for flexible course scheduling. Teachers usually teach a class of students in a local classroom, which is then video-conferenced over a broadband network to other schools within the division.

The Virtual Presence Learning Environment (VPLE) constructed in this school division through the earlier RACOL project is technologically very sophisticated and employs a number of technologies besides video-conferencing. The VPLE enables teachers to respond to individual students and interact in real-time through video. Video is projected to the class through 32" colour TVs, and is used in combination with a SMARTboard. The SMARTboard is an enhanced "white board" that is capable of transmitting graphics, web screens, and/or software application displays to the host class and remote sites simultaneously. Teachers use the SMARTboard to write messages, calculate solutions, and illustrate examples. The VPLE's designers created a state-of-the-art multiple site delivery system, resulting in a rich learning environment similar to face-to-face classroom instruction. Researchers judged this system to be the most technologically sophisticated (and expensive) of the five systems reviewed in this study.

Although predating the deployment of the SuperNet, the FVSD video-conferencing system is based on IP technology that is compatible with the new carrier network (or

commercial Internet). Ken Dropko (2004), who was FVSD's superintendent when the project was conceived, noted: "*We are no longer compelled to accept geography as an excuse for mediocrity, at least when it comes to student achievement.*"

When thinking of the courses offered during the first two years, FVSD administrators noted: "*We probably did too much too soon.*" In their first year, FVSD offered eight courses. In the second, they offered ten. Curriculum included Grades 10, 11, and 12 mathematics, sciences, and second languages, a post-secondary welding course, and a teachers' aide course. In 2004-05, FVSD offered nine courses and plans to offer that same number over the next few years. This is expected to stabilize teacher, student, and parent expectations and make course delivery more consistent.

Bev Hilhorst, FVSD's video-conferencing coordinator (2005-06) anticipates video-conferencing will provide the jurisdiction's students with greater flexibility in course and program planning. Students who are aware of the courses available can plan their schedules in advance, and thus gain valuable experience about planning for their future. Hilhorst notes: "*Students are entering a new age; they are now taking their 20 and 30 level courses back-to-back in one year to free up time for other courses.*" Researchers observed that the skill sets of students are becoming more diverse, and tend to fluctuate based on how individual students choose to design their personal course and program schedules.

Most video-conferencing courses offered (2004-05) were academic high school courses in the Grades 11 and 12 curriculum. The rationale for selecting senior level high school courses was that older and more mature students typically are better able to stay engaged with minimal supervision, and were thus found to be more responsible participants in video-conferencing programming. These courses, however, traditionally serve smaller student populations. Smaller high school schools do not have the specialized teachers required to teach higher level courses, so such video-conferencing programming makes sense in FVSD.

Equipment and Technology

The VPLE configuration specified the overall physical and technical classroom configurations (i.e., layout of student seating, teaching areas, and location of fixed technology devices). Each VPLE in FVSD is nearly identical in terms of technology and furniture used, and each VPLE site is capable of sending and receiving two video streams. Each site sends one MPEG-2 video stream, with the exception of the teaching site, which sends two. Video streams are compressed locally into MPEG-2 format, then transmitted via broadband to FVSD's central technology office, where the videos are then uncompressed and automatically combined using a digital video mixer. The two video streams are re-compressed onto a single MPEG-2 and transmitted to each site, where they are uncompressed locally and displayed simultaneously on several monitors, one located at the front of the classroom, and two monitors located at the rear of the classroom. This physical setup allows students to see a split screen image of all the classrooms involved in the video-conferencing class on one monitor, and a full screen video of the teacher on

a separate monitor. The monitors at the rear of the classroom mirror the front monitors, enabling video-conferencing teachers to see both their local and remote students simultaneously, without moving their body or head.

A unique feature of this central MPEG-2 setup is that video-conferences are monitored and controlled from the central information technology center, located at the central office in Fort Vermilion. Researchers observed that this level of centralization allows technology specialists to monitor remotely, troubleshoot, and fix problems as they happen. A central scheduling system is used, which automatically starts up and connects the video-conferencing classrooms at the beginning of each class. Although this centralized configuration reduced the technical skills needed by teachers and students, it increased their dependency on technical staff.

FVSD's various VPLEs are similarly arranged. Each VPLE suite has an ergonomically shaped horseshoe table (see Figure 1). The video-conferencing teacher stands at the front of the class, where s/he can control the video-conferencing equipment from a customized podium controller. No matter where the students sit, they have a clear view of both of their teachers (either at the remote or host site) and a split screen monitor of other remote sites. SMARTboards are positioned in the middle of the room and are surrounded by the video monitors. This setup allows the teacher, SMARTboards, and monitors to remain constantly within the students' field of vision.

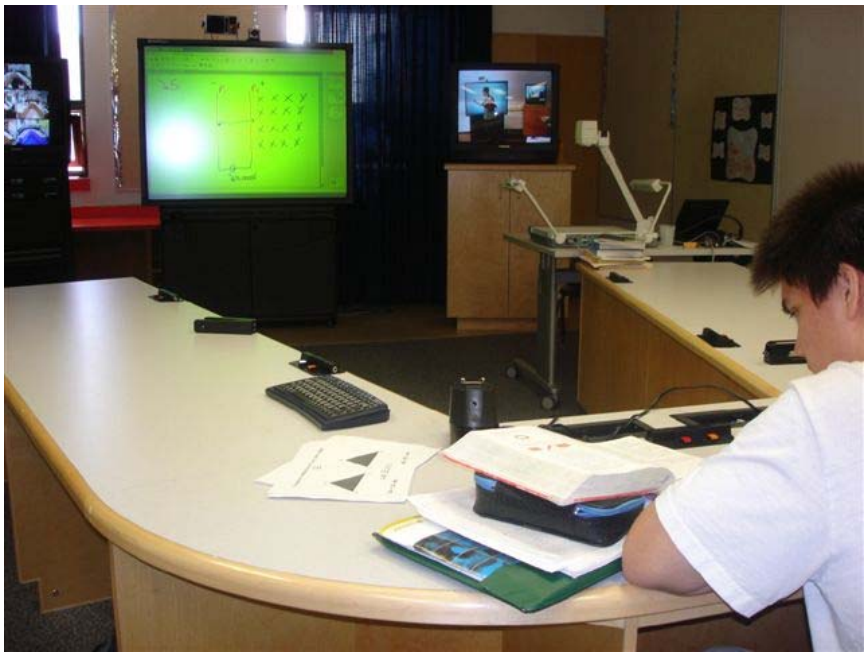

Figure 1. Customized video-conference classroom with question buttons and wireless keyboard.

Each horseshoe table seats approximately 11 students. There are five microphones spaced between the seats for individual students to ask questions, and one ceiling microphone that picks-up the full range of classroom discussion. This audio system was the most complex (and costly) of all systems investigated in this study. The ceiling

microphone picks up background noise, so clear communication between the classes was observed to be difficult at times. Some participants stated that this noise is natural and mimics the noise of a real classroom, while others said that the background noise can be distracting. Video-conferencing instructors used a wireless microphone, which enabled them to move around the front of the classroom without having to worry about microphone position. Despite contentions between natural versus distracting background noises, the quality of the microphones and mixer in the VPLEs was observed to be superior to that used in other school jurisdictions, and generally allowed for spontaneous conversation amongst all participants.

Another feature of the VPLE classrooms is the "question button" located on students' desktops. When the question button is activated, the student's microphone becomes live and a camera focuses on that particular student. This feature is rarely used because of students' reluctance to have their image broadcast to the other sites. Instead, and as is common in traditional classroom settings, students more often blurted out the teacher's name and asked questions. This practice often caused problems for video-conferencing teachers, however. Teachers stated it was often difficult to identify the student and understand the question being asked. They are then faced with the problem of responding to students with blanket comments like: "*Whoever just said that question, please press your question button.*" This puts students – particularly those who are shy – on the spot; researchers speculated this would have an adverse affect on the students' propensity to restate or ask additional questions.

In normal (un-zoomed) mode, the students see their teacher on one monitor, and the students in the other classes on a separate monitor, which is visually divided between the two to four other sites to which the course is being delivered. Similarly, the teacher sees the remote sites in split screen mode. Despite efforts of the VPLE designers to use sophisticated, state-of-the-art video technology, observers found it challenging to identify individual students and interpret their gestures and body language. The single screen, divided into separate windows, was simply too small for quality observation of each remote site.

Each site is identical and is equipped with:

- Four television monitors (two at 27" and two at 32");
- Two video cameras, one presenter camera, and one audience camera;
- Gentner digital mixers to deliver full duplexed echo free audio;
- Rear projected SMARTboard electronic whiteboards – using *Microsoft NetMeeting* for desktop sharing and collaboration;
- Visualizer (document camera);
- DVD/ videotape player (Visualizer and DVD can be displayed on TV and/or SMARTboard);
- Instructor computer;
- Five question buttons with microphone and "I'm lost" button;
- One ceiling microphone that is always on;
- One wireless lab microphone for the presenter;

- Three Polycom Via Video units;
- Three personal desktop student computer stations; and,
- A customized touch control panel connected to the central AMX control unit, allowing control over all aspects of the room(s) during a video-conferencing. This includes moving cameras, selecting video inputs, question button control, and audio control, thus allowing instructor control of local and remote sites.

FVSD is also equipped with Via Video desktop video-conferencing systems intended for desktop collaboration. These desktop video-conferencing units allow for additional student-to-student or individual student-to-teacher interaction; however, little use of this feature was in evidence during researchers' visits.

The centralized control panel controls video-conferencing class scheduling. While this centralized system does not allow teachers to set up their own class, it does get the system up and running and the class going quickly. Nonetheless, if the system goes down, rather than troubleshooting individual classrooms, technical support staff must reset the whole system – including all classes currently in session throughout the division. Teachers or students did not seem empowered to take control of the system and adjust it locally for optimal use. For example, one television monitor was askew during one session researchers observed, yet the students did not seem empowered or motivated to adjust the monitor for better effect.

FVSD was one of the first jurisdictions to receive access to the provincially supported high-speed network (SuperNet island), which worked well for the RACOL pilot study. Increased connectivity between FVSD's schools running on SuperNet fiber optic technology reduces latency and improves connectivity. At the time of researchers' visits, however, SuperNet connectivity was limited only to schools within the jurisdiction, and remained largely unconnected to the larger provincial network. In order to video-conferenceoutside their division, FVSD was using a slower AGNpac connection developed in 2001 by the provincial government. Once the SuperNet is fully rolled out, however, FVSD network configuration will evolve to include connectivity with the rest of the province, although they will face challenges connecting their MPEG-2 based signals with the provincial standard H.323 systems.

Teachers said they would be more satisfied with video-conferencing technology if it could be seamless and not interfere with their day-to-day teaching. Teachers revealed that at first they were of the impression that video-conferencing technology did not require them to change their basic approach to teaching, and that could use their traditional teaching skills with the VPLEs. Researchers observed that such 'sameness,' however, does not reflect additional challenges teachers typically face in managing remote classes, providing learning materials to multiple classes, exchanging assignments and test results. Nor does such 'sameness' address the technical training and the learning curve teachers need to master the system and troubleshoot problems. These challenges also increase exponentially with the number of sites added to a class. Multi-point delivery is inherently more challenging for a teacher to manage than point-to-point delivery. Moreover, teachers face a learning curve in managing multiple remote sites in

both terms of both teaching and technology. Researchers postulate that teachers must learn how to become more self-critical of their teaching activity and presentation within the video-conferencing classroom environment. This includes becoming familiar with how loudly to speak, where and when to move, which technologies to use for specific lessons, and re-thinking lesson styles. Any models developed should recognize both the inherent challenges of teaching in a video-conferencing classroom and the number of sites participating. In sum, ***teachers require support and assistance in using the technology effectively.***

Video-conferencing technology creates an overlap of costs and expenses between schools, which in turn disrupts conventional modes of school-based accountability, pedagogy, administration, communication, and planning. When it comes to video-conferencing, the accountability framework for each school is shared within the jurisdiction. FVSD's central office maintains accountability for the entire jurisdiction by ensuring their students' needs are met and the community is involved in the decision-making process. As a result of local community feedback, both central and local school administrators faced pressures from communities who desire local teachers. This clashes with the jurisdiction's need to share teaching resources efficiently, thus creating tension between local preferences and divisional needs, tensions which must be carefully weighed and balanced.

Technical support was an ongoing challenge for all school jurisdictions using VC technology. FVSD's use of customized technology premised on a centralized control model further exacerbated these challenges. Because their current MPEG codecs are no longer being manufactured, and are incompatible with other school jurisdictions, FVSD will likely have to change the codecs used in their systems to standard H.323 format. Fortunately, new equipment continues to decrease in price.

Applications

FVSD uses its video-conferencing technology primarily to deliver mathematics and science courses to high school students. Video-conferences are offered in multi-point mode, with at least three schools participating in each course. One FVSD administrator explained that, in general, the learning styles and behavioral characteristics of students who tend to enroll in these types of courses lend themselves to the unique challenges of teaching and learning in the multi-point video-conferencing environment. Teachers stated that because these students are typically older and more academically focused, fewer problems are encountered with disruptive behavior, irregular attendance, and misbehavior compared to other courses offered by FVSD to younger groups of students.

FVSD has also taken advantage of the AGNpac broadband network to connect to high schools and post-secondary institutions in other regions. In 2004, FVSD formed a partnership with GYRD to deliver French 13 to students at a high school in Fort Vermilion. In previous years, they connected to a teacher aide course offered by the U of C, and a welding course offered by NAIT in Edmonton. While none of these trial collaborations persisted, the told us they these trial collaborations were useful proofs of

concept. Developing partnerships that make administrative and economic sense to all partners is a greater challenge than technical compatibility. As such, the final RACOL report (Varnhagen & Fuchs, 2004) recommended a external coordinator or volunteer be assigned to partnership development; this recommendation has not been implemented to date, however.

Outcomes

A positive outcome of FVSD's video-conferencing program is its ability to increase student access to a full set of high school courses. One teacher explained that prior to the installation of the video-conferencing Learning Suites: "Chemistry and Biology were offered on a two-year cycle – Biology 20 and 30 one year, and Chemistry 20 and 30 the next. With the video-conferencing system, students can actually get both Chemistry and Biology each year." Interviewees shared that in the absence of these opportunities, families must decide, oftentimes, to leave their local community to continue their children's education elsewhere.

Interviewers heard that there is great opportunity (and need) to develop multi-cultural awareness, understanding, and regional community as an outcome. One FVSD administrator noted: "*Students from diverse communities who don't normally have a chance to interact with each other now have the opportunity to do so daily*". However, there are physical and technical challenges in creating community among widely distributed populations, such as those communities serviced by FVSD.

There are also advantages for the division and its teachers. With a multi-point video-conferencing system and Learning Suites at each of its high schools, FVSD can make the most effective use of its primary resources – its specialty teachers: "*We have specialists in every area*," one teacher explained, "*unfortunately, they're not located at every school. To have a Physics teacher, a Pure Math 30 teacher, and higher-level science teachers is one thing, having one in each school is another*." Challenges of providing specialty, but compulsory courses, are being met using video-conferencing technologies. According to FVSD personnel the video-conferencing system helps them to realize their goal of providing educational experiences that are comparable those available in larger urban jurisdictions.

Keys to Success

When researchers visited FVSD, the video-conferencing system had been operational for two years. Staff and students told researchers that in that time, they had become experienced and knowledgeable with video-conferencing. As such, they felt they could provide suggestions for other jurisdictions engaged in similar projects. Because video-conferencing serves groups that are temporally distributed, synchronization is an important issue with multi-point video-conferencing. Staff advised that multi-point video-conferencing classes must begin and end simultaneously. Events that could be 'picked up' by the Learning Suite microphones should also be coordinated, including buzzers and bells that signal the start of classes, playing of the national anthem, and to the

extent that they can be, announcements on the public address (PA) system. Reporting procedures could also be standardized, so that teachers can prepare and submit students' grades to one central area.

Due to cost considerations, supervision at all remote sites was not feasible for the FVSD. Problems arising from in-suite supervision have been addressed and mitigated in various ways. After permitting a group of 16 students to enroll for a course at one of their sites last year, FVSD staff said that they have since set a limit of 11 students per site. To attract diligent and responsible students, they are very selective about the curriculum they offer through the Learning Suites. They also arranged to have an in-school contact (e.g., school secretary) at each site to ensure the timely and dependable circulation of information and documents between sites. Local school administration is cognizant of the potential need for adult supervision in remote video-conferencing classrooms (e.g., at the request of the video-conferencing teacher).

Finally, as people throughout all school jurisdictions echoed, it is advisable to arrange face-to-face meetings between students and their teachers. In FVSD, dispersed classes meet a couple of times each semester to work on labs, get to know one another, and develop a sense of camaraderie. One administrator reflected: "*Students really enjoy the opportunity to come together. The scheduled lab days help them get the feeling that they are a class, a community of learners*."

Professional Development

Since the beginning of FVSD's involvement with the RACOL project, PD for teachers has played a prominent role. During the funded phase of the RACOL project, face-to-face in-service sessions were conducted throughout FVSD and in Edmonton for teachers engaged in video-conferencing. RACOL staff also facilitated monthly video-conferencing sessions to troubleshoot concerns and develop strategies for effective use. The RACOL project concluded: *"It is also recommended that all teachers involved in VPLE teaching in the school division develop procedures for meeting regularly, both face-to-face and by video-conference, in order to continue their collaborative support for one another's developing knowledge and skills"* (Geelan & Fiege, 2004).

Despite this recommendation, ongoing PD for new and seasoned video-conferencing classroom teachers was not sustained in FVSD at the levels provided during the RACOL project. Activities associated with this community of practice research met a portion of the PD needs, but additional hands-on training devolved to that provided by technical help and other resources. After discussing this shortfall with the FVSD, they made a commitment to provide at least nine PD sessions for the 2005-06 school year and at least as many for next year (2006-07). Faced with increased PD activities, some teachers have seen an increase in workload and hence, scheduling constraints. Some teachers were not able to access the PD activities laid out for them, and many PD activities fell at inopportune times or were not scheduled well enough in advance. Others simply did not attend the workshops, citing them to be unnecessary.

Plans for the Future

FVSD plans to expand their video-conferencing system and are committed to moving the project forward. In addition to the five high schools currently online, they anticipate adding a sixth next year. After connecting to NAIT, the U of C, and GYRD for a welding course, a teachers' aide course, and a high school second languages course respectively, they are exploring options to access additional courses from outside their division. Much depends on FVSD's connectivity with other schools and areas within the province over the SuperNet. FVSD also plans to expand their administrative uses of the video-conferencing system. Distance between schools in the division are significant, and travel can be both unsafe and costly. Thus there is much support and interest for using the video-conferencing system for meetings and collaborations.

As they increase use of their video-conferencing system, FVSD must make changes to their infrastructure. Currently, video-conferencing rooms are booked on nearly a continuous basis, so expansion without a concomitant increase in rooms and equipment will be problematic. FVSD's current system employs an MPEG-2 codec. Unfortunately, the manufacturer of this product has gone out of business, so parts, upgrades, and support are no longer available. Moreover, Alberta Education has recently adopted a different technological standard (H.323) to support video-conferencing throughout Alberta. Efforts to maximize connectivity and increase capacity – even to support current video-conferencing system – will thus be expensive.

The older, un-supported MPEG-2 standard used by FVSD was designed to provide an enhanced picture. Researchers did not observe a noticeable difference in video display quality versus video transmitted over more pervasive H.323 systems. This observation was supported by discussion with FVSD technical personnel. FVSD now finds itself working at the 'bleeding edge'. Their equipment lacks manufacturer support, it has lost the technology standards war, and it will soon be obsolete. The division will need to consider replacing parts of their technology with equipment that meets the H.323 standard. Replacement equipment will be less expensive than their custom designed Learning Suites, however. Moreover, many of their current components (SMARTboards, cameras, audio equipment, etc.) may be usable with the newer H.323 codecs.

FVSD appointed an assistant superintendent to manage the distributed video-conferencing environment. Her job consists of selecting courses and teachers, administering funding for staff and student travel, coordinating schedules, making technical and financial decisions related to the project, and providing central office support and coordination. Without this extra support, it is unlikely that the FVSD's video-conferencing program could have achieved the extensive coordination, technical support, and PD that the jurisdiction currently enjoys.

Inquiry Mentorship Study: Rethinking Reproduction – Biology 30

Reproduction, development, and genetics are topics within the Biology 30 curriculum and formed the basis for the design of the FVSD inquiry-based project. This project was inspired by the research findings of a Canadian research team led by Dr. Roger Pierson, Director of the Reproductive Biology Research Unit of the University of Saskatchewan (U of S) in Saskatoon, which uncovered evidence that suggested the traditionally accepted model of the human menstrual cycle was incorrect. Dr. Pierson and his research team showed that the medical community has "*not fully understood the basic biological processes that occur during the menstrual cycles. We are going to have to re-write medical textbooks. …This work is particularly exciting to us because of the impact it will have on women taking oral contraceptives and undergoing fertility treatment"* (CIHR press release, 2003).

Tasks Developed for Students

A Calgary-based teacher had designed an inquiry study that addressed reproduction and reproductive technologies the previous year. After meeting the FVSD teacher, the GNEA mentor suggested that she might want to join the Calgary-based teacher and address these new findings. The Calgary teacher was the only Biology 30 teacher in her school, and the FVSD teacher was the only Biology 30 teacher in her school and for that matter, for quite some distance. The Calgary teacher wanted to redesign her original inquiry study and valued the opportunity to work with another teacher and with GENA mentors once again. Working in a professional online learning environment for teachers and through a number of video-conferencing sessions with a Galileo mentor, the two teachers began the redesign the project so that it would fit the needs of both teachers and classes of students. The inquiry project can be found at: http://student.myio.org/2169/

Video-conferencing was very successful in establishing a level of trust and intimacy as the teachers and mentor worked closely together in the redesign of the inquiry. All the details were worked out, such as how to introduce the inquiry, the pacing of the tasks, and how to assess the work.

Working in a Blended Environment

The two teachers introduced the study to the students. These teachers wanted to have an asynchronous environment where students could collaborate with each other as they worked through the project, so GENA set up an online discussion community. All students were registered in the online community. The FVSD teacher created the first post in the community and provided students with their first assignment. A number of students created entries; however, they did not respond to or take up the teacher's questions or respond to her directions. Instead they seemed genuinely confused:

"*Hey, where are the kids from Calgary*." [discussion post]

"*What are we supposed to be doing here?*" [discussion post]

"*Can anyone tell me where Calgary is?*" [discussion post]

The online community was not successful for a number of reasons:

- While all students were registered, only a few students from the class in Calgary took the time to enter the online community .

- The decision to incorporate an online asynchronous community came too late in the project.

- The students in Fort Vermilion were unfamiliar with an asynchronous environment. They expected it to be synchronous and were disappointed when it was not.

- A number of students from the Fort Vermilion class were blocked from accessing the site.

Unfortunately, by the time that GENA learned there were problems the teachers were almost finished the study.

Teachers and mentors alike assumed that students would be familiar with asynchronous community environments. However, that was not the case. In speaking with the students later, it was clear that some of them expected a synchronous environment, "*I put something in but no one answered until the next day, so I gave up*" [discussion post]. It is clear that it cannot be assumed that all students are familiar with the various forms of online environments. Students and teachers need to be properly introduced to the various online environments.

Working with an Expert

While the students and teachers were immersed in the study, GENA mentors contacted Dr. Pierson at the University of Saskatchewan. He agreed to meet with the students via video-conferenceto discuss his research work and to answer students' questions. Technicians conducted three separate successful tests between FVSD, Netera at the U of C, and the U of S. Everything was set. On the day of the video-conference the students from Calgary came to the Netera office at the U of C. Everyone connected and then suddenly the FVSD connection was dropped and was not able to be restored. The FVSD students and their teacher, who were looking forward to connecting with their partner class and Dr. Pierson, lost the opportunity to participate in a very valuable learning event.

Needless to say, the teacher and students from Fort Vermilion were hugely disappointed. The information technology manager stated that the planned video-conference to connect

all five schools with their partner school and Dr. Pierson was "*the first time we actually tried to do something really valuable*" [interview transcript].

The video-conference did go ahead with Dr. Pierson and the Calgary school. Teachers and students felt it was "*a dream come true*" [email exchange].

Since a key characteristic of inquiry is working with emerging issues, questions and problems in the world outside school, the planned session with Dr. Pierson was exactly the sort of encounter that video-conferencing is good for. One of the visions for video-conferencing through high-speed connectivity is to bring world-class expertise to all Alberta students, even if they live in remote areas. All Alberta students should have the opportunity to experience learning dreams come true. Jurisdiction policies and network configurations must support such possibilities.

Pedagogically Sound "Plan B's"

Teachers are generally unforgiving when major things go wrong with technology. It does not take too many of these kinds of incidents for teachers to return to more familiar ways of teaching. A question for PD is how to recover when the conferencing technology fails without falling into the trap of creating non-technology 'Plan B's' that make teachers plan twice: once for working creatively with technology, and once with conventional paper and pencil direct instruction approaches.

For example, if teachers and students had been using asynchronous technologies more often, with more success, then the failed connection to FVSD could have been followed-up by connecting the students and themselves after the event. The Calgary students could have shared what they had learned, raised questions with FVSD, and perhaps planned, on the basis of that work together, to contact Dr. Pierson later to continue the questions and answers. The teachers could even have planned a video event between classroom sites for this kind of peer collaboration. That kind of work would have been characteristic of a genuine inquiry.

Without diminishing the importance ensuring that such technical failures are kept to an absolute minimum, this study suggests that teachers and professional development should also factor in "what happens if we are knocked off," ***using the power of the community to find ways to continue building knowledge***. If video-conferencing is seen as only a one-time event with an expert, then the failure of the event becomes irredeemable. But if teachers learn to think more strategically about what matters about the event – in this case, introducing a whole new way to think about ovulation and the menstrual cycle – then the urgency to keep the inquiry moving can motivate alternative ways for students to work together in other synchronous, as well as asynchronous, environments.

Video-conferencing events sometimes place students in the rather passive role as audience for an expert's performance. The remaining case studies reported later in this document demonstrate that there are far better ways to think about the involvement of experts. Fortunately, when teachers focus on the *purpose* of the event rather than the *fact*

of the event, those better ways also help mitigate some of the damage caused by technical failures.

Red Deer Catholic Regional Division No. 39

RDCRD was another early entrant to video-conferencing. RDCRD is comprised of 14 schools spanning elementary, middle, and secondary grades. RDCRD has 11 schools offering elementary education, eight offering middle school education, and three offering high school education, in addition to an outreach centre. RDCRD's head offices are located in Red Deer, a steadily growing city with a current population of just over 70,000. Red Deer is located two hours south of Alberta's capital city, Edmonton, and two hours north Alberta's largest city, Calgary. Along with the city of Red Deer, the division serves outlying communities of Rocky Mountain House, population 11,000, Sylvan Lake, population 9,150, and Innisfail, population 13,600. Students seeking a Catholic education commute from other communities to each of these schools. RDCRD currently serves a student population of approximately 5,900 students.

Setting the Stage for Video-conferencing

Two of RDCRD's three secondary schools are currently involved in broadband video-conferencing: Ecole Secondaire Notre Dame in Red Deer and St. Matthew Catholic School in Rocky Mountain House. Although some courses have been broadcast from St. Matthew in Rocky Mountain House (e.g. an outdoor education course) the majority of video-conferencing courses are taught from the larger Ecole Secondaire Notre Dame in Red Deer.

St. Matthew Catholic School is located in Rocky Mountain House, which is a two-hour drive east of Red Deer. St. Matthew Catholic School is affiliated with the local parish of St. Matthew Catholic Church, and currently serves 580 students. According to one administrator, St. Mathew Catholic School joined RDRCD eight years ago and has been seeking to integrate curricula from RDCRD: "*. . . we were looking to combine resources and make it [*RDCRD*] a more efficient district. . .*"

Faced with the challenge of serving a small student population, staff at St. Matthew Catholic School explained that they were having difficulty providing a full curriculum to all its students on a continuous basis. RDCRD administrators stated that senior academic courses in the sciences and calculus (Math 31) were examples of courses with low enrollments.

For many years prior to the introduction of video-conferencing, St. Matthew Catholic School students supplemented timetables with correspondence courses to meet their academic needs. These correspondence courses were found to be lacking interactive and collaborative elements. Moreover, because these correspondence courses were developed outside the division, they were found to be inconsistent with RDCRD's faith-

based course goals, which are articulated in the schools' principles: *"We take great pride in the Catholic Educational Programming that we provide to our students. We have modeled our educational system after the teachings of Jesus Christ. You will find that our Principles of Practice underline everything that we do."* Seeking to put these principles in tangible action, four years ago RDCRD adopted video-conferencing for distance education provision.

Ecole Secondaire Notre Dame in Red Deer serves a large, urban student population. Opened in 1996, Ecole Secondaire Notre Dame has capacity to serve up to 1250 students, and offers a full complement of academic career and technology, fine arts, French immersion, special needs, and other specialized programs. Unlike St. Matthew Catholic School in Rocky Mountain House, Ecole Secondaire Notre Dame does not face the problem of serving small student populations, nor does it suffer from a lack of qualified teachers to teach specialty subjects. Ecole Secondaire Notre Dame also aims to model its curriculum within the context of the teachings of Jesus Christ, and therefore the use of video-conferencing has enabled Ecole Secondaire Notre Dame to develop and deliver distance education curricula reflective of faith-based teaching. Since it was clear that the jurisdiction was "*looking to combine resources and make it [RDCRD] a more efficient district. . ."* to echo observations made by one RDCRD administrator, it can been viewed as logical that Ecole Secondaire Notre Dame's specialty teachers could be used to teach St. Matthew Catholic School students via video-conferencing technology.

RDCRD was deemed well positioned to implement video-conferencing from the start due to previous experience with distance education. RDCRD had collaborated with Greater St. Albert Catholic Regional Division, and Medicine Hat Catholic Regional Division, via the operation of St. Gabriel Cyber School, which delivers independent study courses to students throughout Alberta and the rest of the world.

Staff at St. Gabriel Cyber School told researchers that they began experimenting with synchronous voice and text-chat as enhancements to their web-based courses. They were impressed with the results of its initial asynchronous, web-based courses. Thus, when talk of the SuperNet began in 1999, through its collaborative activities with St. Gabriel Cyber School, RDCRD found itself well positioned to expand the synchronous components of its classroom-based courses using video-conferencing technology.

Trajectory

One RDCRD administrator described the division's video-conferencing program, which they named *Learning Live*. The project began in the 2000-2001 school year when the Alberta Government announced that the SuperNet would soon be available in their division.

RDCRD personnel first began discussing how they could most effectively and efficiently incorporate the high-speed network into their activities. During these discussions, they considered the difficulties they faced providing a full high school curriculum to all RDCRD students enrolled in all their schools. RDCRD personnel also recognized that

many families in their division were forced to move when their children reached high school age, and that many families ultimately did not return. To address this problem, RDCRD envisioned a fully interactive system that could allow students across the division to take any course they wanted, collaborate with others, and receive immediate feedback from their teachers. RDCRD personnel also recognized that any such system must be reliable and affordable.

With this rationale in mind, and operating on an interim high-speed network provided by the province (AGNpac), RDCRD initially offered two courses via *Learning Live*: English 20 and Math 20. These courses were selected because they did not culminate in a diploma exam; hence, students' academic careers would not be adversely impacted by this experiment.

In evaluating their experience, teachers stated that they enjoyed the opportunity to engage in professional dialogue with their colleagues, and the opportunity to experience working with new technologies. They also mentioned that students requested more opportunities to interact with others at alternate sites.

By the second semester of 2002-03, a new SuperNet island was operational in their division. At that point, RDCRD began offering a full slate of high school courses between Ecole Secondaire Notre Dame and St. Matthew Catholic School (i.e., Legal Studies, Forestry, Religious Studies, and Learning Strategies).

In their third year (2003-04), RDCRD added two more courses: Career and Life Management and Math 31, the latter being their first attempt at multi-point video-conferencing using their own MCU. RDCRD continues to offer each of these courses, and the video-conferencing program is going "full bore" according to division personnel.

Equipment and Technology

Each *Learning Live* suite consists of a television used to display video-conferencing lessons transmitted from the host classroom to the remote location, while the remote location is displayed on a large projection screen located at the front of the host classroom. The following is an account of the technology the research team observed in use during their site visits to RDCRD.

Each classroom site is equipped with:

- one Sony H.323 video-conferencing codec, which allowed each site to send or receive synchronous, high quality fully duplexed audio and video;
- two video cameras: one presenter camera and one audience camera;
- visualizer (document camera);
- front projected SMARTboard electronic whiteboard (or SMART Sympodium) using Bridgit server for desktop sharing and collaboration;
- projector, with large format picture from far end video-conferencing video feed;
- presenter desktop computer;

- one 32” television monitor displaying local site;
- DVD/ videotape player (can be displayed on television monitor and/or projector screen);
- document scanner; and,
- CISCO MCU 3540 with IPVC-3540 MC03A and IPVC-3540-EMP3 for 30+ endpoint bridging.

This equipment is housed in a regular classroom with no custom furniture. Researchers observed, however, that it was extremely challenging for students to hear comments made by students at the other site. Further, they observed that teachers were often forced to repeat or paraphrase students’ questions and responses, primarily as a result of poor audio quality. Researchers felt that the source of poor audio quality stemmed from the number and the placement of microphones in the *Learning Live* classrooms. They were told that an audio upgrade is planned, which will hopefully overcome this problem.

Figure 2. RDCRD *Learning Live* Classroom – note the student on the right who is holding a microphone in his hand, a technique used to support audio interaction in this classroom.

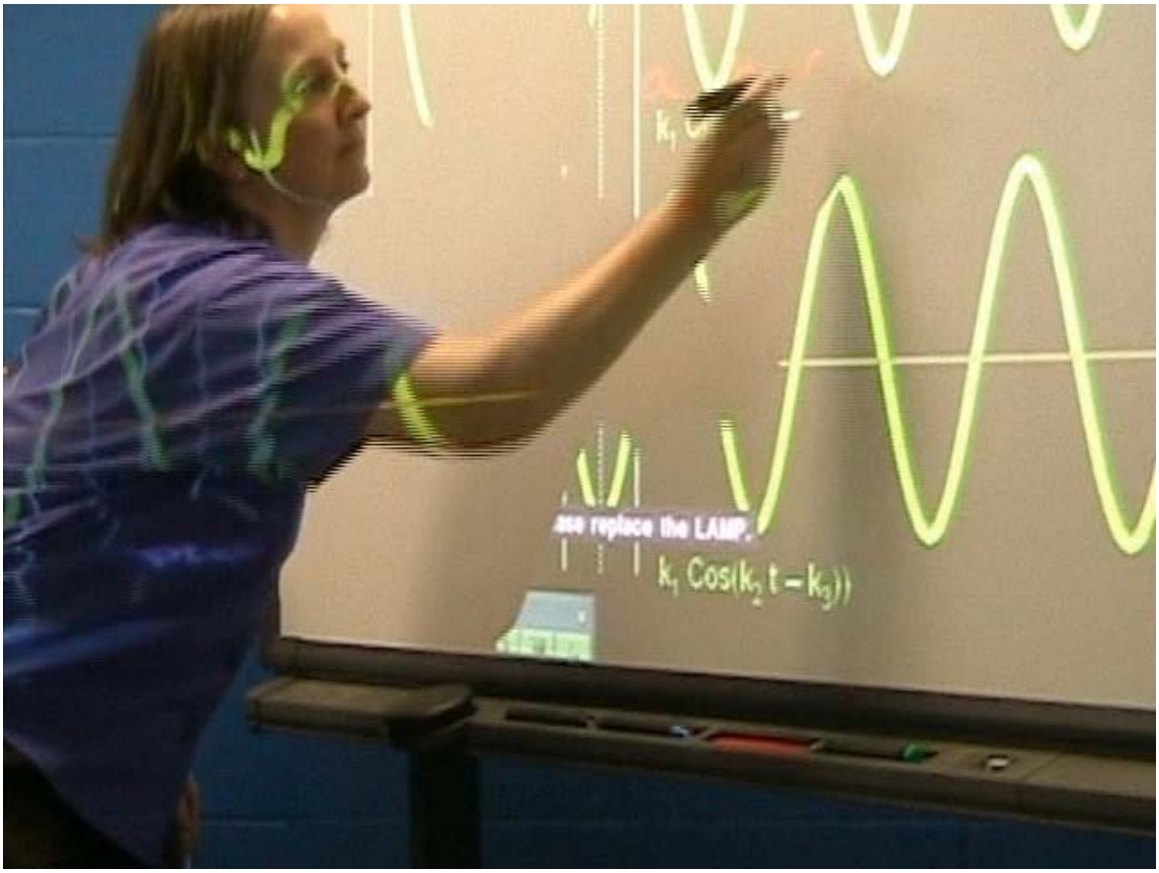

Figure 3. Whiteboard capabilities in RDCRD classroom.

Network

RDCRD is using the SuperNet to connect its video-conferencing classrooms. The jurisdiction is seeking to expand their outreach to include Sylvan Lake and another school in Rocky Mountain House. As the RDCRD network continues to expand and evolve, more schools (along with schools in other school jurisdictions) will be connected to SuperNet. As such, RDCRD is focused on forging external partnerships and assisting schools in other jurisdictions in developing effective video-conferencing projects.

RDCRD has established one of the most cost effective video-conferencing setups that was observed during site visits. RDCRD has opted to use existing classrooms with minimal renovations, which are usually limited to painting and adjustments to lighting. The division has also opted to use a single projection monitor in both its receiving and transmitting classrooms. To date, delivery has been point-to-point, allowing RDCRD to avoid the technical and pedagogical complications of multi-site delivery.

Also unique to RDCRD is the support provided at the remote classroom. A teacher's aide helped with materials distribution and return, setting up and adjusting equipment, and maintaining discipline at the remote classroom. Teachers commented that it was extremely valuable to have the support of a teacher's aide at the remote site.

RDCRD encourages its teachers to visit remote sites on a regular basis (i.e., three times per year). Students and teachers relayed that they found these visits worth well. Teachers reported that face-to-face visits allowed them to regain some of the 'rapport' they felt they had lost with their students at remote sites.

RDRCD had more students enrolled in their distance education classes than the other sites observed. One teacher reported teaching a class of 44 students spread over two sites. Again, most course delivery was initiated from the larger high school in Red Deer (Ecole Secondaire Notre Dame) to the smaller school in Rocky Mountain House (St. Matthew Catholic School). However, teachers also expressed concern teaching large numbers of students (15-25) at a single site, primarily due to the sound quality and limited numbers of cameras. Teachers expressed that it was challenging to have enough detail needed to observe an individual student, yet have a wide enough camera angle to visualize all video-conferencing classroom participants.

RDCRD's hardware system and network is simpler than those observed in the other school jurisdictions. Unlike FVSD where a central technical hub is used to remotely control the technical aspects of video-conferencing set-up and delivery, in RDCRD each video-conferencing machine and peripheral must be started and adjusted by the classroom participants themselves. During the site visit to RDCRD, researchers observed the off-loading of such technical tasks from the teacher to the students, a dynamic wherein two students were left in charge of the volume and another the camera zoom function etc.. Such sharing of responsibility appeared to work very well: students were empowered with the responsibility over the technology needed to support the classroom, and they gained valuable technical skills.

In sum, researchers felt that RDCRD was better able to support larger video-conferencing class sizes than the video-conferencing classrooms observed at the other four jurisdictions. They concluded that RDCRD's success in supporting larger classes was partially due to the use of a teacher's aide at the remote site. RDCRD also demonstrated the capacity to develop a viable program with minimal costs. Improvement to the sound quality in the *Learning Live* classrooms would likely enhance interaction between the sites. Finally, researchers commented that the use of students to set up and operate the video-conferencing technology seemed to empower students while at the same time releasing teachers to focus on teaching.

Applications

Learning Live is used for the delivery of complete distance education courses, currently in a point-to-point format. As RDCRD states in their Education Plan: "*Learning Live is a synchronous interactive environment designed to deliver selected high school courses*." As students and teachers become accustomed to video-conferencing, administrative applications are also being developed and tested. For example, the system was used for professional association meetings and professional development workshops. Using

video-conferencing for board, administrative, and teacher association meetings eliminates participants' travel between cities and towns served by the district.

Outcomes

In keeping with RDCRD's original goals, the most notable outcome has been that students now have access to a wider array of core and elective courses taught in an interactive, collaborative manner that is reflective of faith-based teaching.

Keys to Success

Last year, one of their equipment suppliers interviewed RDCRD personnel. One question this supplier asked was: *What advice they had for other school jurisdictions embarking on similar projects?* At the top of their list of recommendations was the bringing together all the stakeholders involved in the project. They stated that administrators, technology coordinators, and teachers must be given time to sit down and examine their needs.

> *Working with teachers to understand uses of the technology and giving us opportunities to explore applications using real classroom lessons is essential. If you do that, institutional wisdom becomes a part of the project, and your core knowledge base grows* (RDCRD, Administrator).

Plans for the Future

RDCRD plans to expand their *Learning Live* classrooms beyond its high schools to include its elementary schools, which they anticipate will allow younger students to engage in collaborative enrichment projects. Aiming to deliver K-9 French immersion programs across the division, they are also formulating plans to include a school in Sylvan Lake and another in Innisfail. Finally, RDCRD's expertise in Catholic education will allow RDCRD to assume a leadership role with other jurisdictions, and through the provision of faith-based distance delivery content and professional training opportunities beyond the borders of the jurisdiction.

In observation of and brief discussions with students, researchers noted that the microphone situation in the *Learning Live* classrooms was less than optimal. Questions or comments raised by students in the back seats of the larger delivery classroom often had to be repeated or paraphrased by the teacher. Likewise, comments from students at the remote classrooms were challenging to hear. Additional microphones may be required if this deficiency is to be corrected.

Inquiry Mentorship Study: Calculus – Math 31 and Math 35

Calculus is often considered a gateway subject, in that most people who do well in calculus often succeed in college or university-level mathematics. Reaching calculus is often viewed as the crowning achievement in school mathematics, and "preparing

students for the study of calculus has been the central goal of school mathematics" (Stewart, 1990, p.182). This point regarding calculus is highlighted because students who take calculus in high school are often seen to have 'arrived.' So for a teacher to try something different with a group of students who are university-bound presents some significant challenges.

The teachers in this project actively sought out opportunities to deepen their professional practice. One teacher reported having tried "*a lot of different techniques for teaching mathematics and incorporated them* [in her] *classroom: cooperative learning, the project-based, the traditional type, the group learning, and peer teaching.*" What caught this teacher's attention was the possibility that inquiry-based teaching and learning held for her students. She liked the possibility that students would have to think critically about a problem that is posed, solve it in more than one way, consider ways in which the problem opens to new problems, and work together with each other in dialogue, conversation, and debate to solve the problem and defend their solutions. "In an inquiry mathematics classroom, students are actively engaged in the construction of knowledge[1]" (Carter, 2004). One teacher stated that she was very interested in inquiry and "*to have students learning themselves on a topic or a problem that they are really interested in*."

The classroom teachers and their GENA mentor began the planning process together. They determined that they wanted to focus their inquiry into the intersection of trigonometry and calculus. They wanted the students to understand and appreciate that trigonometry and its derivatives live in authentic situations in the world all around us.

It was important that the problems developed for these students contain a carefully considered and constructed element of authenticity. In order to achieve this, the teachers welcomed the mentorship of a calculus expert; this ensured that the work had value beyond the classroom and a place in the real world. By opening up their school subject to an expert in the field, students and teachers had an inside view of the types of problems and questions that engage those outside the classroom.

Dr. Gordon Hamilton, an expert in Biomechanical Engineering from the U of C became involved in the planning. He held a number of telephone conferences with one of the teachers and her GENA mentor. The three participants used telephone for this portion of the planning because they encountered a number of technical challenges with using video-conferencing and audiographic software to reach outside of the school division. Since it would be necessary to involve a technician in order to connect to Dr. Hamilton in Calgary, they decided they could accomplish what they needed to do through a telephone conversation.

In reflecting on the planning session, the GENA mentor stated: "*It was so cool to see what really matters about trig, and how we could go about teaching this two-week unit by taking an inquiry stance. Once we got our heads around that section, we figured out all the important concepts* [the teacher] *needed to cover, sent that document to Dr. Hamilton*

[1] See Scardamalia & Bereiter and Schwartz & Fischer for a full discussion on knowledge building.

and phoned him. Based on the interests of the kids, we came up with some excellent topics that can be addressed through trig" [email exchange].

Tasks developed for students

Dr. Hamilton created a number of original problems that related to real situations from which the teachers could choose, comment on and suggest revisions. Two problems, *Artery Bifurcation* and *Iris and Her Sprinklers,* were sent to teachers by email. As part of the planning process, the teachers provided feedback to Dr. Hamilton. The following is a sample of the exchange that took place between the teachers and Dr. Hamilton:

> **Teacher 1: "***The beginning solution given seems to be using polar/rectangular coordinates. These are not part of the Math 31 course. Can the solution be completed using functions and radians?"*
>
> **Dr. Hamilton: "***The first approximation of a solution (r,theta) = ((e^t – e^-t)/(e^t + e^-t), t) is in polar coordinates. You can read it as two functions, the first gives the distance to the water sprinkler at any time, t:*
>
> *r(t) = (e^t – e^-t)/(e^t + e^-t)*
>
> *and the second gives the angle in radians at any time, t:*
>
> *theta(t) = t*
>
> *Since polar coordinates are not desirable, I'll definitely come up with something else."*

This exchange illustrates an essential feature of mentoring high school teachers: the outside expert and the teacher must engage deeply together in connecting good problems with mandated outcomes, and with the subject discipline itself. As Dr. Hamilton was able to demonstrate to the teachers, there is always more than one approach to a problem. The willingness of both sides to explore multiple approaches is a vital aspect of PD in mathematics, helping to move both teachers and students away from the mechanical application of algorithms into a much more creative space of true understanding. Teachers' expertise in connecting the mandated curriculum to those approaches ensure that the curriculum is, indeed, being covered – a major worry for teachers when new approaches are suggested.

Participating teachers and their mentor selected *Iris and Her Sprinklers* for the planned inquiry into trigonometry and calculus. At their request, Dr. Hamilton agreed to introduce the problem to the students using video-conferencing technology. He presented the problem twice, once to Math 31 students and once to Math 35 students.

Working with an expert

This first video-conferencing was successful from a technical standpoint. Unfamiliar with working with Grade 12 students, Dr. Hamilton did not allow enough time for students to work on various aspects of the problem. In reflecting on the experience, Dr. Hamilton stated that he felt rushed and that he had rushed the students. He was not sure how to call upon the various students in the classes for their responses. The teacher provided Dr. Hamilton with extensive feedback after the first video-conference, which he incorporated into the subsequent video-conference event, presenting the same problem with the Math 31 classes.

The second video-conference using the same problem was much more successful. Nonetheless, there were a number of difficulties with the video-conference itself: "*the technical was a little up and down with JPP and sometimes Dr. Hamilton disappeared and then popped back 15-20 seconds later, but was quite workable*." These difficulties did not interfere significantly with the flow of the video-conference, however.

One teacher saw this as an opportunity to team teach her class with Dr. Hamilton. The other teacher saw this as an opportunity for her students to work with someone other than herself, commenting that "*…it gives them* [her students] *a broader insight to their mathematical learning to see that I'm not the only 'math geek' in the world. For them to be able to see that there are other people that really enjoy mathematics and they get it from another person and that is a very good experience for them*" [video interview].

Working across a large number of sites

Many students found the number of participants in the video-conference overwhelming.

> "*It's hard to really get the full effect of it when you're competing with Rocky and this other guy talking, plus this other class. There's already enough distractions with these guys around here. With other people talking and the mics getting all mixed up and you have to say everything two times or three times or four times. It gets a bit much. When it's just us and Rocky, I think it works alright because it's this class plus four other people. But when it's two full classes on either side, well its just too much*" [student, video interview].
>
> "*Yeah, it's hard because you can't really single a person out and go back and forth because they could say something and somebody a little bit closer to the mic might be whispering and that will take away from them. And the mic thing is not a good way to communicate*" [student, video interview].
>
> "*Well, I don't like the way the technology is not working*" [student, video interview].

In reflecting on this video-conference and the problem with the microphones, teachers stated:

> "*The table mics that we have right now are voice activated and so whoever is closer to the mic their volume will come in through more clearly. As well, we have the flat ones that are 180-degree directed… Well there's a whole level of regular classroom activity that's missing when everything you say and do to a student has to be public. So the idea of having a teacher with a headphone or students with headphones that could be turned off and on so that you could have individual conversations between teacher and student, and student and teacher in the various locations as well, is something that needs to be investigated*" [video interview].
>
> "*When we did it* [video-conference] w*ith three schools and the main speaker, it was difficult to know when to speak and when it was appropriate to bring a suggestion forward when another end was not getting it. They were focused on their point but at that time, the students in the other two classrooms either weren't following what was the problem or else they were thinking other thoughts or just waiting*" [video interview].

As an observer in one of the teacher's classrooms, the GENA mentor noted that: "*It was very difficult even for me as a teacher to track what was going on in all three classes that were attending. I am not being critical of Dr. Hamilton at all. I was wondering about the process and wondering if video-conferencing was really supporting what we wanted to do or if we need to pull back and take another look at it. Dr. Hamilton gave the kids more time to talk among themselves, which was great. But while the kids did do some work together, they didn't really sustain that for any length of time and quickly looked to Dr. Hamilton for answers*" [email exchange].

What became evident in this video-conference is **the number of sites involved in the** video-conference **definitely influences the type and quality of interactions among the participants**. Having three classes and one expert from four different sites presented some unexpected challenges. The opportunity for engagement with the problem, and any sustained inquiry into the possibilities that this problem might present or open, was lost during this video-conference. Perhaps the students summed up the most positive thing that came out of this video-conference:

> "*I thought it was kinda nice to have that different style. It was just a different teacher and I thought that was really nice. Is he from the university?*" [student, video interview].
>
> "I*t was just a new teaching method which was nice to see. And it's nice for us at Rocky because it's very rare to get a Calgary professor driving to our site*" [student video interview].

Mathematical inquiry is difficult to attain at the best of times, as most mathematics comes to most teachers and students as a static predetermined course of study to be mastered through set procedures. The only hope for opening the space for inquiry occurs through

rich problems that open into a space deep within mathematics. This requires that students have time to interact with the problem and with each other, to forward tentative conjectures, to seek out alternative solutions, to present and defend their solutions to their classmates, and to search for new problems that arise during the course of solving this particular problem.

If video-conferencing is to do more than replace conventional 'stand and deliver' teaching in mathematics classes, then serious attention must be paid to the technical requirements needed to support meaningful collaboration across sites. It cannot be assumed that the simple translation of current promising practices in video-conferencing will also work well with inquiry-based tasks and problems for students.

Preparing students for a video-conference event

Teachers wanted Dr. Hamilton to introduce *Iris and her Sprinklers* to the students; it is likely that this use of an expert needs to be supported by regular teachers in a different way. It may have worked better had the teachers, themselves, introduced the problem first and then let the students puzzle over it. Having already worked on the problem individually and in groups, the students could have connected with Dr. Hamilton the day after they encountered the problem, by forwarding a number of possible solutions and ideas.

This method is consistent with changed practices in mathematics teaching supported by research conducted through the *Trends in Mathematics and Science Study*.

In terms of maximizing the use of an expert through video-conferencing, it would have provided Dr. Hamilton with greater opportunity to extend thinking that students had begun in small groups unencumbered by the large number of sites in which students were trying to brainstorm, ask questions of one another, try ideas out, etc.

If, at the moment, the technology supports only a fairly structured form of turn-taking in dialogue, then one non-technical solution is to examine how to prepare students for a video-conference without sacrificing the very kinds of thinking that inquiry demands.

Blended technology solutions

Blended solutions are emerging as important in learning at a distance, where both synchronous and asynchronous environments are used to support various stages in problem-posing and problem solving. In this case, such blends worked well as teachers, GENA mentors, and Dr. Hamilton did their planning and debriefing. Attention should also be paid to the kinds of blended environments that most effectively support student work so that experts like Dr. Hamilton can work with the students over time.

Dr. Hamilton designed a second problem called *Some Interesting Curves* in response to one of the teacher's queries about how to introduce sinusoidal curves. This video-conference involved one class from two sites and the third site from the U of C. This was

a much more successful video-conference. Dr. Hamilton presented the topic of sinusoidal curves to the class, and left them with an exploration to be carried out after the video-conference session.

Figure 4. Students engaged in Mathematical problem solving activity *"Some Interesting Curves".*

The teacher and her students reported that they really enjoyed and appreciated the hands-on aspect of this problem. "*This time*," the teacher commented, "*there was a different level of question. It was more of an introduction to an activity that involved a lot of open-ended questions and the students really enjoyed it. They enjoyed the speaker's humour. They enjoyed the presentation. They went out and gathered the data. They needed very little guidance from me. They wrote it all up and sent it off electronically*" [video interview].

In this case, Dr. Hamilton continued to occupy the important role teachers wanted him to play: introducing a problem in an engaging way that would set the stage for fruitful investigation. It worked very well in this case, since both the introduction and the follow-up activities were designed specifically to take advantage of the differences in learning environments available to the students.

The success of this video-conference also points to an important next step in encouraging the teacher to have students work collaboratively (both synchronously and asynchronously) not only to post their solutions, but also to challenge one another, argue points of view, and try different strategies. This would have strengthened the knowledge-building aspect of inquiry, where students' access to one another online in various environments very readily supports inquiry as a more public, collaborative activity than is typically the case in high school mathematics classes.

Grande Yellowhead Regional Division No. 35

GYRD takes its name from the highway that pierces the division from its eastern to western borders. The boundary of GYRD stretches from Jasper National Park east to Evansburg, and north to the Town of Grande Cache. Included in GYRD's catchment areas are the villages of Niton Junction and Wildwood, and the towns of Hinton, and Edson. GYRD's jurisdiction includes 18 schools and three Off-Campus Centres. The jurisdiction serves approximately 5,000 students. GYRD shares many characteristics

with RDCRD and FVSD. Although slightly larger in geography, the number of schools in GYRD is roughly similar to FVSD and RDCRD, and like FVSD and RDCRD many of GYRD's schools also serve small villages with populations under 800.

GYRD systematically began their video-conferencing program in 2001 with a modest investment in entry-level technology, which they placed strategically throughout the division. Proceeding conservatively and with due consideration for cost effectiveness, sustainability, and success, GYRD has developed a comprehensive video-conferencing program, which jurisdiction administrators claim sustains itself financially through its pervasive use for course delivery, administration, and community activities. In sum, GYRD gains economy of scale by extensive use of its video-conferencing system for direct course delivery, administrative use, and community use.

Setting the Stage for Video-conferencing

Faced with serving small populations and declining student enrolment at many of its schools, GYRD administrators began examining ways to support administrative applications in its widely distributed jurisdiction, as well as devising alternate forms of course delivery. In 2001, GYRD launched its video-conferencing program – a few years before the Alberta SuperNet arrived in their region. Moreover, over the past ten years, the GYRD has taken a leadership role in developing networking opportunities not only for itself, but also for other partners (e.g., Adult Learning Consortia, Health facilities, etc.). GYRD was technically well prepared to incorporate and expand video-conferencing capacity for educational purposes with the arrival of the SuperNet, and it was politically positioned to share their video-conferencing system with existing community partners.

The principal objective of GYRD's video-conferencing program is to provide its students with a comprehensive array of optional curriculum. Within this objective in mind, GYRD personnel were extremely clear on how their system should work. First, GYRD personnel knew that their jurisdiction's video-conferencing system must be easy for teachers and students to use, it must be reliable, and it must be affordable. To ensure sustainability, GYRD's video-conferencing system was designed strategically to benefit multiple stakeholders: schools, teachers and student, administrative, and the community. This collaborative approach was consistent with GYRD's vision, which states among other things that "*. . . Governance and management are based on a model of civil democracy that involves parents, community, students and staff in planning, problem solving and decision-making to ensure that the jurisdiction is financially secure, with contemporary programs, services and facilities.*" (For GYRD's full vision statement, see: www.gyrd.ab.ca/vision.html)

Trajectory

Progress of the GYRD's video-conferencing system was guided by a *graduated model,* wherein each phase of the model focused on gradually increasing video-conferencing

usage across the division, and gradually enhancing technical sophistication of their video-conferencing system.

A description of GYRD's video-conferencing project trajectory can be found on the jurisdiction's website:

> *"In January and February 2002, entry-level video-conference hardware (i.e. H.323) will be installed in Jasper High School, Grande Cache High School, Harry Collinge High School, Parkland Composite High School, Niton Central, Grande Trunk High School and the Education Services Centre.*
>
> *A main focus includes professional development seminars among our community schools, and administrative meetings and conference sessions after regular school hours and on non-operating Fridays/weekends. Network connections will be maintained on the government-sponsored AGNpac T1 links to Jasper, Grande Cache, Hinton, Evansburg and Edson. To ensure that the video-conference sessions can access required network connections and bandwidth, Innovation and Science has committed to a redesign of Grande Yellowhead's access as an interim step to SuperNet access.*
>
> *An additional focus is research on distance education utilizing video-conferencing at the high school level. A number of conceptual planning sessions will be completed to determine feasibility of and appropriate integration of video-conferencing in an enhanced teaching and learning environment among Grande Yellowhead's high schools.*
>
> *Conceptual trials will be initiated on the division's 45Mbps/10Mbps wireless network segments over the next 18 months. Participating groups include the Edson Off Campus Centre, Parkland Composite High School and Niton Central School.*

During a site visit, GYRD personnel expanded upon the above description. Researchers were informed that GYRD's video-conferencing project was launched in 2001 on the existing network infrastructure, AGNpac. At that time, two forms of entry-level equipment was purchased and installed. One form was room-based video-conferencing equipment, which included an MCU, Polycom ViewStation FX systems, document cameras, and 32" monitors. These rooms were established at seven sites. The other form was desktop video-conferencing equipment. Professional quality desktop video-conferencing units (n = 40) were distributed to principals, administration teams, counselors, school technology contacts, staff preparation rooms, and classrooms.

Once both forms of equipment were operational, they were evaluated. From this evaluation, users reported they were pleased with the performance and affordability of the point-to-point and suite-to-suite video-conferencing configurations. Users also

reported that the point-to-multi-point video-conferencing configurations were found to be satisfactory for business use. Based on this assessment, GYRD's principals began discussing needs that could be effectively addressed with video-conferencing delivery technology and formulated plans for teacher in-service technology training sessions.

In the 2002-2003 school year, the Government of Alberta provided GYRD with interim access to the SuperNet. By February 2003, video-conferencing equipment was installed and operational in each of the division's high schools and its educational services centre.

Video-conferencing technology use is focused on three applications: teaching and learning, professional development, and administration. For teaching and learning, the jurisdiction's focus is on the delivery of high school courses (Grande Cache-to-Jasper delivery of Math 31 and a Grande Trunk-to-Hinton Central delivery of science curriculum are two such examples). PD applications include collaborations between specialist teachers, seminars among community schools, and teacher and union meetings. Finally, the jurisdiction's administrative uses include routine staff meetings and strategic planning sessions to determine how video-conferencing can be used to enhance teaching and learning throughout GYRD.

Citing that they were pleased with the progress of video-conferencing throughout the jurisdiction, GYRD personnel stated that in the 2003-04 school year they expanded their teaching and learning, PD, and administrative uses of video-conferencing. The video-conferencing project also continued the secondment of a teacher-researcher to coordinate the project, provide training and personal support, document the jurisdiction's successes and challenges with its video-conferencing activities, investigate pedagogies that capitalize on the attributes of video-conferencing delivery technology, and analyze students' experiences with video-conferencing technology.

The full-time secondment of a teacher charged with leading their video-conferencing program appears to be one of the key drivers behind the success of the GYRD video-conferencing program. This seconded teacher has a small budget to pay for students and teachers travel expenses. He is involved hands-on in scheduling and time tabling decisions with local principals, and facilitates PD and training activities for new and experienced video-conferencing teachers. Finally, he is the first line of support for teachers, students, or parents encountering problems or expressing concerns with GYRD's video-conferencing system. In sum, this graduated model of video-conferencing systems development has led the region to its current state of 'success', in which video-conferencing plays an essential role in administration, PD, teaching and learning, and community access.

In the 2004-05 school year, the following courses were available via video-conferencing:

- Six Career and Technology Studies (CTS) modules
- Eight second language courses (including French, German, Japanese, and Cree)
- Two high school mathemathics courses
- One high school physics course

Community groups have also made use of GYRD's video-conferencing facilities. The Yellowhead Regional Educational Consortium, Powerhouse Further Education Council, West Yellowhead Alberta Winter Games Committee, community libraries, and other community groups use GYRD's video-conferencing system to convene meetings and conduct special events.

Equipment and Technology

GYRD calls its video-conferencing system "3-V", which stands for *Voice Video Vantage*. Because GYRD's 3-V suites can broadcast up to four individual sites, each site is equipped with four 32" television monitors. These 32" television monitors are mounted on mobile television carts, so various classroom arrangements can be created and optimized according to the needs of individual video-conferencing classrooms. Tables and other devices are mobile and can be similarly arranged to suit teacher and student preferences.

The design of GYRD's 3-V suites allow students to view their instructors in a full screen environment on one television monitor. Up to three remote sites can be viewed separately on each of the three remaining television monitors. Due to bandwidth concerns, researchers were unable to observe this particular application being used during their site visit. Instead, the 3- V sites observed were either using a less bandwidth intensive point-to-point video-conferencing model, or a multi-site split screen model. In spite of not be able to observe the video-conferencing classroom set-up wherein four individual monitors were dedicated to four individual sites, it is possible that the completion of the SuperNet build in the GYRD will enhance this multi-monitor, high bandwidth video-conferencing model.

Figure 5. A Professional Development meeting at GYRD.

Each GYRD site is equipped with the following:

- PolyCom FX 4 H.323 multi-point video-conferencing units
- Five 32" monitors and Polycom FX, which allows up to four streams to be displayed on individual monitors
- One video camera
- Vizualizer (document camera)
- Rear projected SMARTboard with overhead data projector; access to central Bridgit server for collaborative sessions.
- VCR
- Analog audio mixer
- Two area boundary microphones, which can be muted locally
- Multi-function printer/scanner and fax machine
- Telephone

GYRD also has a number of Via Video desktop video-conferencing systems in use throughout the division for administrative desktop collaboration.

GYRD has a Central Dialing Directory, a meeting room manager, and an MCU for multi-site conferences. This facility is located in the town of Edson and coordinates research

and development work; this facility also hosts the 48-point MCU. This Central Dialing Directory has been expanded to include new areas, and GYRD has been developing a hosting solution for inter-divisional connectivity (i.e., 3V-VC VPN that supports E.164, IP+ext, and URI Anneo 0 dialing with cascaded gatekeepers on divisional edges and a central gatekeeper/call processing server).

All GYRD schools will have a hardware-based and dedicated video-conferencing codec (not personal video-conferencing) for September 1, 2005. In addition, all GYRD's high schools have a dedicated hardware codec for distance education and another for administrative uses. At GYRD's Education Services Centre in Edson, four meeting rooms are equipped with video-conferencing and support technologies. Specialized units in the division, such as the Hinton Learning Services Centre and Student Support Services Centre, also are connected to the GYRD video-conferencing system. To support collaborative planning and in-service sessions, central administrative buildings have been constructed to ensure that administrators and consultants have access to all schools from their work centers via video-conferencing.

GYRD is currently using a combination of wireless and wired network configurations. They have created a 3V_VPN that allows bandwidth reservation and management. This network was first established using older AGNpac connectivity, but has now migrated to the SuperNet.

Applications

GYRD designed their video-conferencing system for administrative functions from the outset. With an eye toward course delivery, they also wanted to ensure that the system was reliable, that users were familiar with its operation, and that the system could pay for itself. As in FVSD, face-to-face administrative meetings involve extensive, sometimes treacherous travel. One administrator made this very point clear during the planning of a site visit to two of their schools:

> "*One thing to consider is that the trip from Grande Cache back to Edson in the evening during January may be a bit ugly. Grande Cache is 150 km north of Hinton, and there is NOTHING and NO-ONE between Hinton and Grande Cache. If the weather is good and the roads are good there should not be a problem, other than the possibility of running into the herds of caribou that winter in that area. If the weather or the roads are questionable, it would be safer to stay in Grande Cache overnight and then come back to Hinton during daylight hours*." (GYRD Administrator)

Costs associated with travel, accommodation, and time away from school, are compelling reasons for GYRD's use of their video-conferencing system for administrative purposes, such as meetings. Moreover, the ease and cost effectiveness of organizing meetings results in more fluid communication throughout the jurisdiction.

Lately, however, administrative uses of GYRD's 3-V system are starting to show strain. This means that as demand for video-conferencing grows, more data must be managed from its central system. Additionally, there are more operational issues that must be addressed within the scalability of the entire GYRD video-conferencing system.

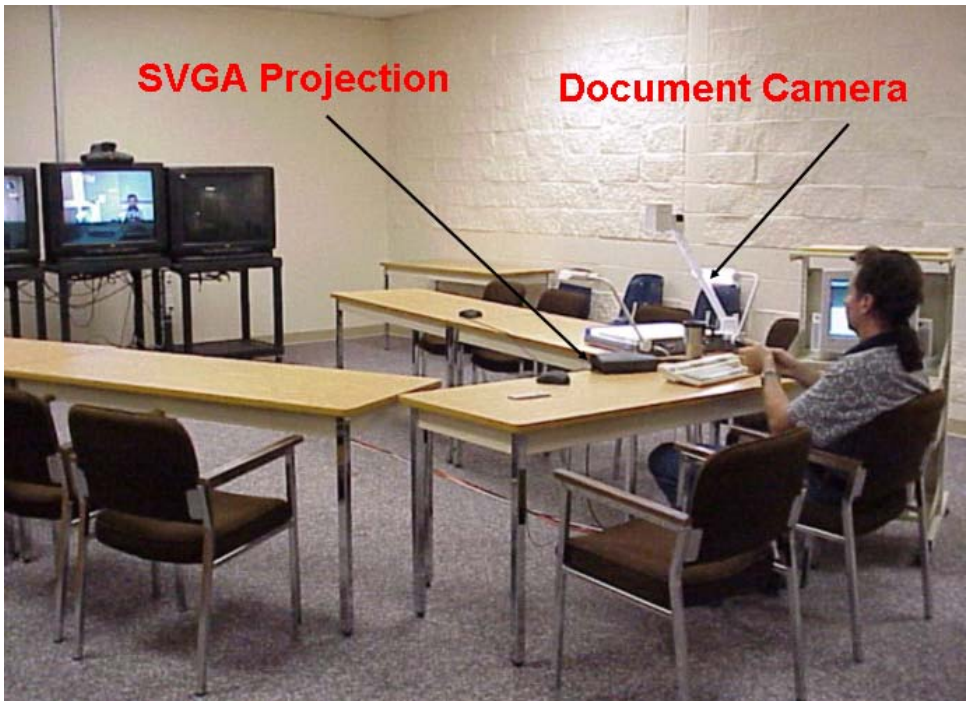

Figure 6. **Typical 'portable' video-conference room.**

Outcomes

There were four main benefits of GYRD's VC program, as seen through the eyes of the researchers. First, students had increased access to a widening array of optional courses presented in an interactive, paced environment. Second, personnel met without the expense and inconvenience of extended travel. Third, community organizations accessed the system and realize savings in time and travel costs. Finally, PD activities were more commonplace as teachers embraced new ways of using this technology.

Keys to Success

Financial sustainability of the video-conferencing program, the growing number of courses, students, teachers, and community groups that are involved in the program, and the central role video-conferencing plays in daily administration, are key indicators of success. GYRD offer several reasons outlining their success with video-conferencing.

Foremost is that discussions among administrators and teachers on video-conferencing started early and continue to this day. Also critical to successful teaching and learning

experiences is support. Reflecting on a list of success factors, one administrator noted: "*Support, support, support is what I'm saying, I guess. Support for the teachers, the students, the technical staff, and the administrators.*"

Another point was mentioned during a site visit to one GYRD school that also came up in each of the other jurisdictions and in the literature on video-conferencing. "*Teachers need to get out and teach from remote sites at least once a month. You need to get students together in meaningful activities as often as possible. The human contact really makes the experience come alive for them*," one administrator commented. This suggests that funding and support for these site visits are critical to the success of video-conferencing use for educational purposes; however, it may be unreasonable to expect the principal of a local school to cover such expense from a school-based budget, and may instead be better managed and borne from a central source.

On a technical level, GYRD personnel noted that backup equipment is essential. Echoing previous research examining video-conferencing, they stated that audio is the most important element in a video-conferencing classroom because most participants can abide less-than perfect video, but poor audio can effectively shut down a conference. GYRD recommends a full screen for each remote site, and they are working toward this in their jurisdiction (this should be achievable with the increase in bandwidth afforded by the SuperNet). Full television screens for each site becomes problematic, however, if the number of sites increases beyond three. GYRD personnel understand the challenges of creating an effective multi-point teaching/learning environment; they stated that three sites (whether in full screen or split screen) is optimal at this stage.

Plans for the Future

GYRD is engaged in examining the impact of video-conferencing on all aspects of their jurisdiction. Administrative applications clearly continue to be an important use. Course delivery, however, has taken priority, with 16 courses set for delivery this year, involving six teachers and 200 students. Looking ahead, GYRD plans to extend their video-conferencing network to their elementary schools, and to add a second video-conferencing suite to their larger schools. GYRD is also planning to extend their 3V program beyond their jurisdiction, with the aim of enabling the exchange of teaching expertise with other jurisdictions, and accessing course and resource enhancements from outside their jurisdiction.

Goals for GYRD's 3-V program are also maturing. Having moved beyond their rudimentary goals of implementing a functional and reliable system that provides access to courses, GYRD's current goal is on understanding and improving student participation, satisfaction, and achievement. As such, GYRD personnel are focused on the creation of classrooms dedicated to video-conferencing, and creating greater interaction between diverse user groups.

GYRD is also undertaking an initiative to facilitate and support inter-divisional video-conferencing. To date, however, very little work has been done to determine exactly how

different jurisdictions will able to communicate with each other using video-conferencing. There are two main obstacles to overcome.

The first and foremost is security. School jurisdictions' computer networks in Alberta are tightly controlled and locked down by firewalls designed to safeguard and protect digital assets and user privacy. Digital video-conferencing, on the other hand, requires the authorization of a high-speed connection to these secure networks. This means that users from outside a given division may be denied access as they encounter the firewalls designed to protect digital assets and user privacy. Thus, considerable technical innovation will be required to seamlessly permit authorized video-conferencing streams from selected external sites, while at the same time maintaining overall security of each division's network. Many sites (especially those sites for course enhancement use) may be located at other SuperNet sites, on the high-speed research networks (CA*net 4, Internet2), and on the commercial Internet.

The second problem can be more easily resolved and relates to the challenge of finding the IP address for a site with which one may wish to connect. There is no equivalent of a telephone directly to look up these addresses. Establishing and building provincial-wide database of resource addresses at VCAlberta.ca should overcome the second problem.

Edmonton Public Schools

EPS is unique among the five jurisdictions described in this multiple case study. Operating in Alberta's capital city, schools in EPS are neither rural nor remote. Unlike the other jurisdictions observed in this study, as Edmonton's population approaches one million, many (not all) schools in EPS contend with burgeoning class sizes rather than small and decreasing enrolments. EPS does not have problems attracting and maintaining specialty teachers; instead, EPS has a waiting list of hopeful teachers. EPS' interest in video-conferencing, therefore, does not stem from their need to deliver courses, but rather their desire to enhance classroom learning. Sustained by their own unique population of learners, each of the EPS schools studied uses video-conferencing technology to enhance classroom experiences, and to meet learners' specific needs and interests.

There are over 200 schools in the EPS system. Of these, three schools have established video-conferencing projects and an additional four are scheduled to begin using video-conferencing this year. This study focuses on three schools currently using video-conferencing: 1) J. Percy Page High School, 2) Victoria School of Performing and Visual Arts, and 3) Centre High. Because each school's video-conferencing program is unique and independent, they are described separately.

Setting the Stage for Video-conferencing

J. Percy Page High School received funding from CANARIE, an organization founded with federal government funding from Industry Canada and the Department of Canadian

Heritage. The objective of CANARIE is to develop network-enabled applications that advanced Canada's position in four strategic areas: e-learning, e-business, e-health, and new media. In their successful funding proposal to CANARIE, members of J. Percy Page High School described their school and their students: "*We serve a multi-cultural, low-to-mid socio-economic community,*" they began. "*Many of our students have not had success in traditional classrooms. We are concerned about our students' dropout rates, their communication skills, and their ICT skills. Students need an educational delivery method that combines technological skill development with a highly engaging method of teaching and learning.*"

Since its initial funding from CANARIE in 1999, staff members of J. Percy Page High School have been instrumental players in the Advanced Broadband Enabled Learning (ABEL) professional learning program. ABEL links teachers and university education faculties together with the goal of developing and supporting rich interactive events among Canadian schools and the larger community.

Information on its use of video-conferencing is outlined in the EPS information package (see http://www.vcalberta.ca/community/EPS_videoconf.pdf), which explains how each of the three schools implemented models to fit within the three essential ABEL components outlined as:

> **1. Online Learning Environments:**
> ABEL (http://www.abelearn.ca) and VCAlberta.ca (www.vcalberta.ca).
> The online environment facilitates learning by connecting students and teachers to research, tools, and inquiry-based collaborative projects. Teachers, students, and experts are part of a learning community that exchanges resources, ideas, and expertise anywhere, anytime. This online environment keeps people and institutions connected during and between PD activities that take place via video-conferencing. Educators use the online environment to share resources, participate in discussions, and plan/book video-conferences. This environment combines broadband applications (video-conferencing, video streaming) with Internet resources (collections, management systems).
>
> **2. Professional Learning Program:**
> The ABEL professional development program is job-embedded, accredited by post-secondary partners, reflective, and teacher driven. The program has teachers and faculty working collaboratively with students in the classroom, while engaged in professional learning. This program focuses on improving student learning.
>
> **3. Research and Evaluation**
> This component of ABEL measures the success of project implementation, and the impact on teacher/faculty and student learning.
> (Edmonton Public Schools, 2005. p. 4).

ABEL's three guiding components have driven each of the schools' development strategies. Each school adapted the components in unique ways based on the methods

used at their school, student characteristics, programs, and infrastructure in place. Schools coordinated their individual plans with the long-term strategies of their supporting agencies. This integrated approach supplied many of the schools with access to support and mentorship on how the technology could be designed to positively influence and enhance learning outcomes.

Staff and administration at each school are engaged in ongoing technical development and PD. It is within this context that staff members at J. Percy Page High School regularly engage in large group video-conferencing events on topics such as tool use, project-based learning, video-conferencing techniques, and small group, subject-specific video-conferences.

From its Telelearning Centre, J. Percy Page High School also hosts *Leadership Link*, a series of events in which teachers, administrators, and technical support personnel observe J. Percy Page High School's VC events, and receive hands-on training with VC equipment. Launched in 2003 as a provincially funded program, *Leadership Link* is dedicated to providing ongoing PD on areas relating to broadband. The intent of these broadband activities is to translate access to PD for teachers into learning opportunities for students. J. Percy Page High School offers these sessions to various members in the community of practice, and has a growing list of interested participants. As J. Percy Page High School embarks on new frontiers of teaching and learning, both Centre High and Victoria School of Performing and Visual Arts have been mentored on several aspects of teaching and learning in a video-conferencing environment.

Personnel at J. Percy Page High School articulated a vision describing what they hoped their program would accomplish. They wanted students to enhance their learning and to develop their information communication technology (ICT) skills. Within the ICT framework, teachers listed several skills: knowledge and use of advanced networks and broadband applications, the ability to create and deliver multimedia presentations, and the ability to communicate through video-conferencing. At a general level, J. Percy Page High School hoped that the synchronous connections to others would deepen students' learning and facilitate the integration of in- and out-of-class learning.

Trajectory

Video-conferencing in EPS K-12 schools began in J. Percy Page High School. In 1999, the school formed a partnership with a local Internet Service Provider (ISP) that provides T1 fiber optic connectivity to the Internet and to Canada's high bandwidth experimental network CA*net II and 3, along with other services such as website hosting, email accounts, and PD experiences. Beginning with a single computer, in 1999 small groups of students at J. Percy Page High School began connecting to other advanced classrooms across Canada.

The following year, J. Percy Page High School began their *Global Classroom Project* in which students developed video-conferencing projects to share with students from across the country. In 2000, their efforts were bolstered when J. Percy Page High School joined

CANARIE's federally funded *LearnCanada* program. In 2002, J. Percy Page High School joined ABEL. The goals of the ABEL project were to enhance student learning by linking high-speed networking, teacher training in technology skills, and innovative pedagogies. ABEL's specialty was collaborative projects among students and teachers from schools across Canada. In 2003, J. Percy Page High School made a successful proposal to the SchoolNet Network of Innovative Schools (NIS). The NIS program provided K-12 schools throughout Canada with moderate funding and consultation services in support of their ICT projects. Specifically, the SchoolNet NIS supported research, mentoring, and information dissemination activities within J. Percy Page High School's program.

Building on the success of its participation in these federally funded programs, in the spring of 2003, J. Percy Page High School opened its *Telelearning Centre of Excellence*. This centre has six state-of-the-art video-conferencing labs, each connected to a national high-speed, broadband network (CA*net). It also includes their Global Classroom, a multi-functional room that converts from a traditional classroom to a theatre seating 180 students. Funding for the centre came from a grant from Alberta Infrastructure and from EPS.

The teachers from J. Percy Page High School expressed that the learning experience for their students was much more meaningful. They said that when students were given the choice to research something that interested them, they jumped at the opportunity. Teachers stated that they felt they had to challenge their students to learn something new, but also allow them enough freedom to get comfortable with a topic of their own choice.

J. Percy Page High School is the only program visited in this project that has developed a series of three-credit high school courses designed to allow students to learn practical skills in planning and implementing video-conferencing technology. The recommended skills and interests for (CTS) Global Classroom 10, 20, and 30 are:

- Communication
- Teamwork
- Research
- Comfort with computer technology
- Leadership skills

By developing a unique CTS course, the school provides its students the opportunity to learn valuable skills. This course has produced teams of talented and energetic producers, recorders, narrators, and other skilled individuals needed to facilitate effective video-conferencing events.

Equipment and Technology

EPS is unique in that each site has a different technological setup. J. Percy Page High School, for example, has a dedicated video-conferencing room, the Global Classroom equipped with one Polycom FX H.323 video-conference system. The school also has a

VIGO desktop video-conferencing device. The other EPS schools visited are equipped with VIGO desktop video-conferencing solutions. All of EPS' video-conferencing sites are portable, meaning they can be moved and set up at any school, which allows for a high level of flexibility that meets EPS' diverse needs.

Like other early adopters of IP-based video-conferencing, EPS has advanced its video-conferencing technology over the years. EPS initially started with an Isabel video-conferencing software application running on a Red Hat Linux box at J. Percy Page High School. They then stepped into the H.323 world of video-conferencing with a VIGO desktop video-conferencing system running Meetingpoint and V-point software. Currently, J. Percy Page High School has a Polycom FX, while the other schools in the division are continuing to use the VIGO desktop video-conferencing systems.

EPS is continually seeking to enhance their video-conferencing technology. The following is a list of the technologies observed during site visits to EPS.

J. Percy Page High School – Global Classroom

- One Poylcom FX H.323 video-conference unit
- Two video cameras
- Two projectors can display local site, remote site, or computer desktop
- Two monitors which can be set up to display local or remote site
- Two area boundary microphones
- One amplified local audio PA system
- Two Instructor computer stations
- Laser printer
- Multiple Student Desktop computer stations
- Lighting is set up as needed depending on video-conferencing events
- Additionally J. Percy Page has added a second videoconference unit (Polycom VSX with television monitors).

Figure 7. East side of the *Global Classroom in JPercy Page High School* – note the use of personal computers in addition to video-conferencing.

Center High and Victoria School of Performing and Visual Arts

- VIGO Desktop H.323 video-conference systems connected to a laptop on a cart
- Various other technologies to handle display, audio, etc, depending on location used for portable system

EPS currently uses dedicated NeteraNet/ CA*net 4 connections in each school. These connections are centrally located and can be routed to any room within the school. As SuperNet connectivity continues apace throughout the jurisdiction, EPS Network configurations will evolve and provide connectivity across the EPS division, and to other schools on a proposed SuperNet VPN. EPS also plans to continue its partnership in the ABEL program and maintain access to the national high-speed test-bed network operated by CANARIE.

Like the customized facilities observed in FVSD, the purpose-built Telelearning Centre at EPS' J. Percy Page High School is an impressive teaching and learning facility. The Telelearning Centre features six learning labs (30 stations in each), two of which can be expanded to seat 150 people. The video-conferencing rooms are designed to allow large and small group participation in video-conferencing events, so flexibility is important. While some video-conferencing rooms have stationary technology that cannot be easily moved, in other video-conferencing rooms the technology is portable and thus provides more flexible video-conferencing classroom arrangements. Much of the funding for the Telelearning programming at J. Percy Page High School came from external sources, including private sponsorships and federal grants. The Telelearning Centre has become a

showcase facility that is used for a variety of PD and exposure session to other teachers. However, it is unlikely that other video-conferencing facilities can be built to match the quality of technology and innovation found at J. Percy Page High School. Indeed, video-conferencing facilities at the other high schools typically consist of low cost, room size units mounted on portable carts, which provide minimal connectivity for occasional use and/or for smaller groups of students.

EPS has also seconded a technology specialist teacher to coordinate their video-conferencing efforts. She has produced a useful video-conferencing information guide (http://www.vcalberta.ca/community/EPS_videoconf.pdf) that provides useful background information, teaching guides, lists of benefits, and a planning guide which principals can use to develop their own rationale, implementation plans, and budgets for video-conferencing enhancement.

Centre High

Centre High plays a distinctive role in Edmonton's school system; it serves students who have not completed Grade 12 at the end of their 12th year of education. Centre High offers a supportive atmosphere that helps these students obtain their diplomas and make the transition to college or the job market.

Along with J. Percy Page High School, Centre High also joined the ABEL program in 2002. They were intrigued by J. Percy Page's use of video-conferencing, and when the EPS offered to connect two schools to a national broadband network, Centre High accepted. "*Any supplementary resources we can bring to help our students*," explained an administrator, "*we'll get them*."

Centre High uses its video-conferencing system primarily to participate in events that have been organized by other schools. However, they have used their video-conferencing system to support presentations by members of the Edmonton Police Service to their students – an event that would have been quite costly otherwise.

Victoria School of Performing and Visual Arts

As its name suggests, Victoria School of Performing and Visual Arts focuses on visual and performing arts, as well as academics. It is a K-12 school that offers curriculum in subject areas such as visual and graphic design, video and audio studies, music, drama, and animation. It also offers an International Baccalaureate program.

Ten years ago, a teacher at Victoria School of Performing and Visual Arts with a professional interest in media and communication technology involved students in a video-conferencing project. The school's current program, however, did not "officially" begin until they joined the ABEL project in 2002. At the time, they were intrigued by J. Percy Page High School's innovative use of video-conferencing, and they were in a situation to take advantage of the technology. Indeed, their principal was supportive,

their teachers were knowledgeable about communications media, and a previous administrator had installed fiber optic cable throughout their buildings.

The Victoria School of Performing and Visual Arts video-conferencing program has evolved considerably since its "official" inception in 2002. The school's approach towards this new technology remains consistent with their previous strategies aimed at integrating technology. The video-conferencing in an EPS Information Package (Edmonton Public Schools, 2005) outlines Victoria School of Performing and Visual Arts' expectations with video-conferencing technology:

> *The opportunity for interdisciplinary work and team building has been unique. The project has brought staff together to work on integrated projects and cross-curricula ventures with students. It has also been instrumental in providing professional growth for teachers in the area of technology and communication. The use of video-conferencing and an array of leading edge broadband online learning tools have benefited staff and students alike.* (p. 15)

Victoria School of Performing and Visual Arts continues to take advantage of video-conferencing technology, as they extend their school's technology resources and enhance their capacity to integrate video-conferencing into their classrooms and curriculum.

In the course of their progression, the initial six teachers involved began communicating some of the functions of video-conferencing technology to other teachers and colleagues, who in turn became interested in the technology. Teachers at Victoria School of Performing and Visual Arts began requesting training on video-conferencing technologies and asked to be included on video-conferencing projects. Due to increasing internal interest and support, some of Victoria School of Performing and Visual Arts' projects began receiving external recognition. Various groups from across Alberta began voicing an interest in connecting with Victoria School of Performing and Visual Arts' collaborative video-conferencing initiatives. Examples of the interested groups included artists from the Banff Centre, students and scientists with an Ontario school and the Ontario Space Centre. Within EPS, Victoria School of Performing and Visual Arts also engaged in several events hosted by J. Percy Page High School.

Applications

J. Percy Page High School, Centre High, and Victoria School of Performing and Visual Arts all use video-conferencing to enhance their students' classroom experience. These schools use project-based and inquiry-based pedagogical models. These enrichment activities center upon two key principles. First, students are empowered as producers, camera operators, moderators, and hosts to engage with a special guest or remote classroom. Students at these schools are not mere consumers of media, but media producers. Second, the pedagogy is inquiry-based, meaning that a relevant, authentic topic is researched by local students before being questioned, debated, and shared with expert speakers and/or students located in similar classrooms across the country (i.e.,

DNA replication, Kyoto protocol, HIV awareness, and the Holocaust). Guest speakers, such as Robert Bateman (Canadian wildlife artist), and Gwynne Dyer (Canadian journalist and historian), have led students through presentations, workshops, and debates. Additionally, schools from across Alberta and Canada collaborate on long-term projects. Several such projects are featured on the schools' websites and on national forums.

Professional development has been a central element of the ABEL community and EPS' video-conferencing activities, with J. Percy Page High School taking the lead in initiating these efforts. In this context, staff at J. Percy Page High School regularly engage in large group video-conferencing events, focused on topics such as tools use, project-based learning, video-conferencing techniques, and small group subject-specific video-conferencing. From its Telelearning Centre, J. Percy Page High School also hosts *Leadership Link*, a series of events wherein teachers, administrators, and technical support personnel observe J. Percy Page High School's video-conferencing events, receive hands-on training with video-conferencing equipment, and obtain mentoring on several aspects of teaching and learning in a video-conferencing environment. Several other regular and special PD activities are reported in J. Percy Page High School's Network of Innovative Schools summary (Industry Canada, 2005). This leadership role, along with the original seed funding from CANARIE, have helped J. Percy Page High School earn a national reputation as a leader in effective video-conferencing use and practice. J. Percy Page High School was also the only Alberta school to receive the national *SchoolNet Network of Innovative Schools Award* in 2003.

Outcomes

When researchers visited EPS, they were informed that during the past year, over fifty video-conferencing events had been hosted by J. Percy Page High School, and several others had been staged at Victoria School of Performing and Visual Arts. EPS personnel are convinced that students' ability access to guest speakers, their ability to get involved in authentic projects, and their ability to work on collaborative projects with other students from across Canada via video-conferencing, have greatly enhanced their learning. Currently, EPS is collecting data on student retention rates and measuring how video-conferencing enhancements can influence the depth of learning, technical expertise, online literacy, and ICT skills. They also report anecdotal evidence: "*A math department head reported that she 'got the best student work and results from pure math 30 students' that she has ever witnessed in her career*" (Video-conferencing in Edmonton Public Schools Information Package, 2005). Also, many teachers engaged in the ABEL project report their excitement with the discovery of a tool and a supportive community that they feel has radically changed their teaching practice. This spirit is captured in the quote from a teacher in ESP video-conferencing report, which proclaims, "*We are changing schools. We are changing education as it can be delivered to our students –in a way that is more meaningful and relevant. That is an amazing task.*"

Because it connects real people in real time, video-conferencing allows for the immediacy of information that many students crave. Some teachers commented to us

that students are able to see the "bigger picture" in the video-conferencing environment. They can break free from traditional barriers in education and reach out to research their areas of interest. One teacher told us:

> "*Video-conferencing can work wonders for establishing credibility to a lesson or connecting students to ground-zero. Students are more interested in hearing about an event from someone who is at the scene, than having me tell them about what happened at so and so. Another example is when we talk about an author in English and I say that author has been dead for 100 years, and then we study a different author and connect to them in a live video-conferencing environment. It really places the students at ground-zero, and this is where they like it*."

ABEL Project's Final Research and Evaluation Report: Executive Summary (ABEL, 2004) discusses some of the various student outcomes:

> *Video-conferencing proved to have a notable, even dramatic impact on most students' engagement levels in ABEL projects, and not just during the video-conferencing event itself. Students reported finding video-conferences interesting and exciting; they enjoyed opportunities to see and talk to students from other schools and regions, and to discover differing regional views on topics and issues being studied (such as energy use and conservation). They were also highly attentive when experts or participants in significant events participated in a video-conference. But the novelty of the medium, which no doubt contributed to the student excitement, also had a tendency to limit meaningful dialogue, as most students appeared quite inhibited about speaking "on camera" – a reaction that would likely diminish given greater exposure to the experience.* (p.5)

Along with collecting data on student retention rates, and measuring how this can affect the depth of learning, technical expertise, online literacy, and ICT skills, EPS teachers are also developing excellence in video-conferencing teaching through hands-on training sessions, sharing of promising practices, and research.

Figure 8. Enhancement video-conference at J. Percy Page High School.

Illustrated in Figure 8 is the technical difference between a distance education and an enhancement model. Note the large screens and larger video-conferencing room, capable of seating up to 50 persons. Also, note the use of the video camera with a dedicated (student) operator. The remote expert guest is using graphics to illustrate his point. Finally, notice that the students must move to a microphone to ask a question – a routine activity found in larger auditorium style delivery, but uncommon in distance education classes.

Keys to Success

Personnel in J. Percy Page High School, Centre High, and Victoria School of Performing and Visual Arts share similar opinions of what elements are needed for successful delivery of a video-conferencing program, the first and foremost being "support." Teachers told us they need supportive administrators who will give them adequate time and resources to prepare for video-conferencing events. They need skilled technicians who will patiently work with them through their first few events, and be available on-call to provide on-going support in subsequent events. Guest speakers also need support: "*Having resources for them* [guest speakers], *working with them ahead of time, advising them on the appropriate level of material, how to make the* video-conferencing *interactive* [is essential]," explained one administrator.

Teachers also need a supportive network of other teachers who have engaged in similar projects and who understand the particular challenges associated with video-conferencing, both within a school and externally. The ABEL community via their website, email discussion list, and summer conference, has served as a useful vehicle for sustaining the sense of community, professional support, and development needed for

successful video-conferencing outcomes. Indeed, part of the challenge of developing a similar community of support around the VCAlberta.ca website may be related to the fact that there is overlap between this community's aspirations and those of ABEL. Researchers are of the opinion that teachers will likely not support two networks, and thus it is suggested that a strategy for linking the national and a more provincially focused network be developed.

Dependable and effective technology is also important: "*Some of our best laid plans definitely went astray due to technological failures*," reported one administrator. When recalling times when they were unable to make or maintain a connection, or when there were problems with audio or video, the administrator said: "*We have learned that there is a price to pay when you want to be at the cutting edge*."

The participating schools in EPS have also benefited from their membership in several federal programs, including LearnCanada, ABEL, and NIS. These programs provide three critical resources: funding, expertise in the technological and pedagogical aspects of K-12 video-conferencing, and a community of researchers/ teachers who invigorate and propel local innovation and activity.

EPS has documented their enhancement programming and provided a list of promising practices and a planning guide. This material, along with other useful information and resource guides, are available online (see http://dtp.epsb.net/ABEL.htm).

Plans for the future

J. Percy Page High School, Centre High, Victoria School of Performing and Visual Arts, and EPS described many ideas for how they would like to proceed. At the jurisdiction level, plans are underway for expanding the program to additional schools. Talmud Torah School, for example, has been participating in ABEL events and several collaborative video-conferencing projects as it builds its own system. Old Strathcona High School is developing a plan to offer PD for its International Baccalaureate teachers using video-conferencing, and Queen Elizabeth School will use the technology to provide student services throughout the division.

Victoria School of Performing and Visual Arts expressed that they seeking to increase the number of events it organizes and to engage in international projects with schools in the United Kingdom and the United States. Currently, they are working with the renowned wildlife artist, Robert Bateman, to develop a curricular module in which their junior high and high school students get to know their wild neighbours through art, and learn more about the science of their local neighbourhoods. Centre High's program is growing, and they are looking for feedback on current and future uses of video-conferencing. J. Percy Page High School will continue with its collaborative, project-based events and its guest speaker events; they are also seeking to strengthen their PD program, which they offer to K-12 personnel throughout Alberta.

Inquiry Mentorship Study: The Conics Around Us – Math 30

Conics is typically a difficult topic for students, who often struggle to understand the relationship between the geometric and algebraic representations of conic sections, and to see the relevance of either. As this J. Percy Page teacher said,

> *"…one of the difficulties for me has been, it's so packed that often I'm not so sure if students really get the real applications that are associated with the math. Why are we doing this? I don't want to look at kids and say, 'It's on the diploma.' Right? I want to be able to stretch beyond that and see there's a real reason – it surrounds you every single day – as to why you're doing this and that was kind of the idea*."

Tasks developed for students

The teacher and Dr. Sharon Friesen, the GENA mentor, developed this study using a number of digital technologies: e-mail, video-conferencing, and an online, collaborative environment for teacher planning.

They discussed the topic itself at some length, looked at the curriculum expectations together, explored a number of websites and then designed two tasks. Students:

1. captured images of the conic sections around them using cameras, drawings, etc., and presented those images through a large display to which they would refer to throughout the unit.

2. explored the various algebraic representations of each of the conic sections. They learned and performed the various procedural computations by linking these algebraic representations to the geometric images they had collected and displayed.

Teacher response

The teacher reported that the task engaged the students. "*They came up with stuff I never thought of. I think one of the things that amazed me the most with this project was when you teach, when you're dealing with a class of students you have high ends, you've got middle, you've got some lower ends of kids. This project seemed to blur those lines*" [video interview].

In addition, the teacher noted that through the inquiry, she and her students had become co-inquirers: "*I've learned things from my students. That's good. That's powerful when we're both learning from each other"* [video interview]. This represents a much more dynamic relationship between students, mathematics, and the teacher than most students see in their senior high school mathematics classrooms.

The teacher noted the powerful ongoing working relationship developed between the teacher and her GENA mentor through the medium of video-conferencing technology in one-to-one professional development.

> "*…as I said, Sharon really helped. …she got the brain flowing a little bit more and challenged me as a teacher and so I think from that perspective, that is really important*" [video interview].

Student responses

Students also reported that they found the task more engaging:

> "*I definitely liked it better. It's way more hands on. Like if you study for hours and hours, if that's only the one concept you know how to learn it, then its not gonna change anything. But this way, it was a new angle to like go about learning and so this learning strategy probably works better. It's more visual than just reading over and over again. I like this better, this is more my style of learning*" [video interview].

> "*Well, it was different. Nobody is sitting in class doing the same thing everyday. Just getting questions and learning how to do the math. Like there was something new to do and we're still learning at the same time. It definitely gave me a better understanding.*" [video interview].

All of the students reported that the project helped them to connect mathematics to the world, an essential goal for this inquiry. This success can be summed up by this comment: "*Well, I didn't realize it at first. Normally, I'm thinking, like what am I gonna use math for? And stuff like that. And, like, when I got this assignment, I realized there's a lot of math that is there – sports and almost everything*" [video interview].

Many students also stated that they believed that they learned better as a result of this project. "*This way is better for me than just tests and stuff because all the other units, I just studied and stuff and with this one, I did the best because of this other way*" [video interview].

Video-conferencing used for PD

Video-conferencing was used as an integral part of the planning process, and had a positive effect on building the kind of relationship between mentor and teacher that permitted the teacher to take considerable risks in adopting an inquiry stance to the teaching of conics.

The link between teacher PD and student outcomes in learning about conics and in improving attitudes to mathematics suggests the importance of further investigation into the power of video-conferencing as part of quality professional development.

Prairie Rose School Division No. 8

PRSD runs along the eastern boundary of the province, stretching north of Hanna, south of Manyberries, and east of Suffield. A few years ago, this vast division went through the temporary closure of two schools, which were subsequently reopened with the hope that SuperNet and video-conferencing would provide an economic means to allow the schools to continue in operation. Faced with these challenges, administrators, teachers, students, and parents throughout PRSD looked forward to seeing how they could utilize this technology to provide a solid academic program, even for the most isolated communities.

During their initial meeting with PRSD, the research team was met with optimism and determination one could expect from those embarking on a new experience. On the technical side, PRSD's schools were prepared, having made purchases of video-conferencing equipment. Anticipating that they could cut down on the amount of travel time needed to cover the extensive distances for their meetings, principals had already started to use the technology with central office. Central office staff, principals, and teachers in each of PRSD's five schools and communities that were going to implement video-conferencing gathered in a series of town hall meetings in each of the participating communities. There was strong community and school support and anticipation for the potential start of video-conferencing in January 2005. These five schools would initially be involved in the distance delivery of a Grade 9 Social Studies class through video-conferencing. The teacher involved was going to move through each of the schools during the semester, so all students enrolled in this class would have the opportunity to engage in for face-to-face interaction with their teacher, at when their school was the host broadcast site.

The community consultation model that used town hall meetings to engage the PRSD's professional learning community was successful in establishing initial support. Unfortunately, many of these plans could not move forward due to the delay in the roll out of the SuperNet (upon which video-conferencing connectivity was based). Plans for implementation of the first video-conferencing teaching sessions have been put on hold until September 2005, in anticipation that SuperNet will be in place in all schools throughout PRSD. The challenge will be to re-energize those who have already expressed such strong support for the video-conferencing.

Equipment and Technology

PRSD has created a number of identical Learning Suites throughout their jurisdiction. Each Learning Suite contains the following:

- Polycom FX H.323 video-conference unit
- Polycom Viavideo II H.323 desktop video-conference unit
- Polycom Visual Concert
- Visualizer (document camera)

- Front Projected SMARTboard using Brigit server for desktop sharing and collaboration
- SMARTboard/Instructor Computer with wireless keyboard and mouse
- 32" Monitor
- Second Projector with projection screen
- DVD/ VCR combo
- Second computer with via video II for one on one conferencing session between teacher and student or student and student if necessary.

PRSD plans to use the Alberta Education MCU to deliver its multi-point video-conference sessions.

When the SuperNet connectivity in PRSD is completed, they will be running their video-conferencing courses entirely over SuperNet.

The delay in the arrival of the SuperNet to PRSD caused the implementation of video-conferencing to be pushed back. As a result, an addition to this report will be made in 2006 to document and assess the implementation in PRSD, which involves a case study investigation of the uses of video-conferencing for junior high school instruction and provision of speech therapy services.

Case Study Discussion

Across the five jurisdictions, two distinct models of video-conferencing for instruction emerged: (1) full course delivery for distance education and (2) curriculum enhancement for regular classroom delivery. Some overlap was found between models in a few of the jurisdictions. For the most part, however, there has been clear direction as to how the models are being used. In four of the five jurisdictions, video-conferencing technology is used almost exclusively for course delivery. In these particular jurisdictions, the reason for beginning a video-conferencing program is to offer their students continuous access to core and optional curriculum. Rural jurisdictions often encounter problems attracting and retaining teachers, particularly for curriculum such as high school science, mathematics, and second languages. Moreover, school jurisdictions and parents do not want their children to have to pursue education outside their community, simply because some courses are not available locally or because qualified instructors are not available. Nonetheless, parents and students often do not support the correspondence alternative either, because they feel it offers a lower quality of learning (RACOL, 2004). The use of video-conferencing to combine and leverage limited resources to create quality educational outcomes for all involved is viewed as a viable and acceptable alternative.

In urban jurisdictions, video-conferencing is envisioned primarily as a means to enhance curriculum. Some users are convinced that collaborative projects with students from other provinces, and interactive demonstrations with experts throughout Canada increase students' (and teachers') engagement in their courses. Because teachers are relatively new to this type of collaboration, they are just beginning to utilize the strengths of connecting their students to subject matter experts across the world. Access to almost

infinite subject matter via video-conferencing is the cornerstone of the enhancement model.

All but one of the jurisdictions visited had been operating their video-conferencing program for several years, and each of these video-conferencing systems was running at maximum capacity at the time of our visits. These video-conferencing systems begin in the morning and operate continuously throughout the day. Moreover, special programs were offered during the lunch hour, and some courses were delivered after regular school hours. In some jurisdictions, the video-conferencing system was used during evenings and weekends by jurisdiction personnel or community members for administrative purposes.

Two paths were taken to get to the point where the jurisdictions are today. One division began with a wide array of courses and then narrowed their focus to only those courses that worked well in video-conferencing environments. Most jurisdictions, however, began with a limited set of test-pilot activities (typically courses with no provincial departmental examination) and expanded their use incrementally. Only when personnel were comfortable using the technology with small groups of students, or when administrators became accustom to engaging in extra-curricular projects, did they make the leap to more regular, centrally scheduled uses of their video-conferencing systems.

An overview of video-conferencing in the five jurisdictions shows the flexibility of this technology. In some jurisdictions, VC is used for curriculum enhancement, and in others for course delivery. Typically, high school level mathematics, science, social studies, and second language classes are the most commonly taught courses using video-conferencing technology. However, there is little evidence that video-conferencing technology cannot be used as a vehicle to support distance delivery for any number of secondary school courses.

Aside from its central role in teaching and learning, all of the jurisdictions observed employed video-conferencing for PD and for assorted administrative functions and meetings. Some jurisdictions even extended the use of their video-conferencing technology to local community groups by opening up their video-conferencing facilities after hours on the weekends and during the evenings. Video-conferencing was also used to support meetings among administrators, staff, and community groups in the rural and remote jurisdictions. Because travel in these jurisdictions is expensive, time-consuming, and at times perilous, video-conferencing offers a viable and cost-effective alternative.

Generally, jurisdiction personnel are convinced that the money spent for video-conferencing technology provides good educational value. Rural and remote jurisdictions have increased the number of core and optional courses. Urban schools are involving their students in innovative educational activities.

During the one to five years that these systems have been operating, division personnel have learned some valuable lessons about the keys to a successful program. The list is lengthy and the items are often specific to a certain division or school; however, two

common themes emerged. First, a common suggestion was that several levels and types of support were needed for teachers, students, guest speakers, technical personnel, and administrators. Second was the demand for reliable, high-quality equipment.

Looking ahead, every division plans to extend their current video-conferencing programs. They spoke of adding more video-conferencing courses (and teachers and students), more equipment and better facilities, and more schools to their existing programs.

Many schools were interested in forming partnerships both within their jurisdiction and with partners from outside their jurisdictions who could benefit from their video-conferencing program. Many video-conferencing administrators and principals felt they were video-conferencing -savvy, and were looking for opportunities to extend their reach or educate more youth. The potential for collaboration is there and many schools recognize this potential. Some of the larger schools want to assist smaller schools that do not enjoy the same level of access to resources, subject matter experts, or specialty teachers.

Section 4: Discussion of Issues

This section contains a discussion of the following issues:

1. Video-conferencing technology
2. Multi-point delivery
3. Interaction
4. Student engagement
5. Comparisons to other modes of education

This section must be prefaced with a caveat: Much of the following discussion deals with problems. Researchers did not direct the participants to speak only of the problems they were experiencing. Most of the questions were either open-ended prompts or balanced queries about the positive and negative aspects of video-conferencing. Nonetheless, problems figured prominently in their responses. This is not unusual. More importantly, it is not an indictment of the use of video-conferencing in these jurisdictions. Aspects of a technology or process that are working well are transparent to participants. Indeed, *transparency* is often regarded as the definitive indication that an innovation is successful. It is not expected that invisible aspects of a technology would provoke the same amount of feedback as visible aspects. Participants offered valuable insights to reflect upon in order to improve teaching and learning with video-conferencing in K-12 settings.

Video-conferencing Technology

The equipment was a significant part of the participants' experience with video-conferencing. When participants described their experiences to researchers, four issues arose: novelty, reliability, and the quality of the video and the audio quality.

Novelty

Many students and teachers were in the midst of their first video-conferencing experience. Some participants were excited initially by the technology. Students thought it was "funner" and "pretty neat." The equipment made video-conferencing more diverse and offered some improvements over conventional teaching. Participants said that PowerPoint slide shows were superior to overheads, and that electronic SMARTboards were better than physical whiteboards, although it must be noted that these technologies are in use in many classrooms that are not using video-conferencing. Many participants felt they wanted the same equipment in their conventional classrooms: "*I would love to have a SMARTboard in every room in this school; it would be so awesome – and one of those visualizers, too*!" explained one teacher.

For some, the initial video-conferencing experience was simply odd. Some participants reported that watching themselves and others on the television monitors, and interacting with teachers and students through video-conferencing, to be an unusual experience.

Two teachers told us that the experience was nerve-racking and scary, especially in their initial experiences. "*I felt quite jittery the first day,*" one said. "*It probably took me a month to be comfortable in there.*" Teachers told us they coped with their angst in similar ways: they donned a brave face and tried to keep things as predictable as possible. "*I put on a façade for the students like everything's OK, and tried not to treat it any differently that a regular classroom. For the first few classes, we just played with the cameras and got to know each other, that kind of stuff.*"

Participants said that eventually the novelty with the technology wears off. When this happens, equipment and processes fade into the background, and it is at this phase in the learning curve that some participants were more reflective. One student told stated: "*It takes a bit to get used to it – the other people watching you up on the screen – but I'm used to it now, so it's fine*." Another student said: "*At first it was kind of weird talking to the teacher through the TV and seeing her on the screen, but after awhile it just became part of the class. It's really no different from a regular class once you get used to it*."

On the other hand, other participants reported that they were disillusioned once the newness wore off. "*It seems like a good idea when you sign up,*" one student said, "*but it loses its luster fast. By the second week, I was over the fact that it's cameras and monitors and stuff, and then I realized maybe I'd made a mistake and should have taken it in a real classroom. It's like watching TV for an hour and a half.*"

Others, however, remained supportive. One explanation for these differing attitudes toward video-conferencing technology may have to do with how it is used. While the following student talks about his transition from excitement to boredom, he also provides some insight into why he felt this way: "*When I first got in here, I thought this would be a fun class; I thought it was going to be a lot better than an actual class. But then we started watching movies every second day – that put me to sleep. I should've just taken this course with a teacher who would actually teach me things instead of trying to learn it through movies and reading and stuff.*"

In the eyes of many Net-generation students, technology is a compelling and interesting part of their lives – thus explaining their initial interest. Educational technologists, however, have long argued that it is not the technology, but how it used, that makes a difference to learning. This argument is supported by research (Clark, 1994). In the distance education classes that were observed, video-conferencing technology was used almost exclusively by the teachers. Researchers observed little opportunity for students to control, present, or otherwise engage with the video-conferencing technology. Instead, teachers controlled and used the video-conferencing technology in many different ways. Moreover, it was observed that teachers using video-conferencing technology tended to embrace the familiar by recreating a physical classroom using video-conferencing. Most teachers observed during site visits tended to use a "presentation and question and query" pedagogical method. It was seen that there are significant challengesin creating a constructivist environment in a distance delivery model of video-conferencing implementation.

Reliability

Equipment problems were a common topic raised during interviews with video-conferencing participants. These problems were described as transient, but with so many pieces of equipment in use during a given video-conferencing session, it seemed to some participants that there was always something that was freezing up, slow or simply not working. For some jurisdictions, in the "slow category" was the electronic whiteboard: "*When you write on it, it looks like you're in grade-two and just learning how to write; it's all jaggedy*" one student reported. More disruptive was the tendency for parts of the system to freeze, necessitating a lengthy rebooting procedure. In the final category – "not working" – participants from across the jurisdictions identified occasional problems with almost every element of the video-conferencing system perceptible to them: microphones, speakers, cameras, monitors, projectors, electronic whiteboards, personal computers, desktop video-conferencing units, the network, and visualizers. *"I'd say we've had our visualizer up and working correctly for the whole class about half the time*," reported one teacher.

Participants' impressions of the frequency of problems ranged from a "couple of times" and "sometimes," to "all the time" and "every time." One student complained: "*It sucks when something's not working, and there's always something's that's not working*." Conversely, another student was more forgiving: "*It's just little things, like our microphone is not working sometimes.*" Teachers tended to be less descriptive about the frequency or seriousness of technical problems they encountered. One teacher said: "*The batteries in the mouse died once* (laughs). *It's nothing serious. The whiteboard connection is loose or whatever, and you kind of have to fiddle with it for the light to come on. And, the warning light on our projector has been saying that the lamp is about to burn out, but it's been saying that for over a month. We really haven't had any technical problems.*"

Some students resigned themselves to experiencing ongoing problems, while others noticed improvements over time: "*The technology doesn't mess up as much as it did at first*," one student explained. "*They must have done something to stop it from freezing and always having to reboot. In the last two and a half months it's only frozen like two times. At the beginning, it froze four or five times a week – definitely more than once per class.*"

Temporary disruptions bother some participants more than others. One student told us: "*There are quite a few kinks in this; but it's the first year so things should smooth out*." Another demonstrated remarkable flexibility: "*There is a couple of times when something goes wrong, but I'd say it's usually pretty good. For instance, the lamp's starting to burn out on our projector, but when it does we'll just stop using that*." Other participants were not as tolerant. "*Little things happen all the time and I just wish it would always work. It's frustrating*."

Students' frustration stems from what happens while problems are being addressed. When teachers were well prepared in advance with a meaningful alternative, or when the problems were addressed quickly, there were few complaints. Most complaints heard were voiced from students who had done too many worksheets or had done nothing at all while technical problems were being resolved. "*When something goes wrong with the camera*," one student explained, "*we can't do our work for however long it takes them to fix it. Like, sometimes we get signed off, and we have nothing to do. After that, I just want to go home*."

Students in one division stated that their teacher was very adept at fixing technical problems. At most sites, however, most problems are addressed by a technical support technician working off-site. Fortunately, technical support was able to resolve most issues quickly from a distance. "*Basically it's a quick phone call to the IT department at the central office*," one teacher explained. "*They're very good about it, and video-conferencing is always a priority. Generally they respond within minutes, which is good*." While technical problems are being resolved, teachers adjust and resort to the backup plans. One teacher said: "*If something goes wrong*, [technical support] *can usually fix it in a few minutes. But when they can't, you have to have a backup, plan 'a,' 'b,' and 'c,' and so on. I usually have my PowerPoint presentations ready, and if that doesn't work, then it has to go on the electronic whiteboard. And if I want to show something on the visualizer and it doesn't work, then I have to be able to zoom in on whatever I want to show them so they can semi-see what I'm doing. Yeah, you have to be a lot more prepared.*"

It is unreasonable to expect any new technology to work 100% of the time. In their quest to offer participants teaching and learning experiences similar to found in the traditional classroom, the jurisdictions have been equipping their video-conferencing systems with a wide array of medium to highly complex tools. Used by themselves, these technologies are typically very reliable; but when used in combination it seems that one or more are not working. Fortunately, the jurisdictions visited were aware of these problems and had developed technical support teams to provide troubleshooting, rebooting, and diagnostics – most of which can be performed at a distance. This level of support, however, can be expensive and is not 100% reliable, thus demonstrating the need for the development of contingency plans for teachers and technical staff when the video-conferencing system goes down. For example, during the site visits, researchers found that none of the jurisdictions were able to fall back easily to an audio-only solution, as could be supplied through the telephone or IP-based audiographic systems. Development of such contingency plans may well be worth investigating and supporting on a jurisdiction – or even provincial – basis to ensure that video-conferencing classes continue apace during video-conferencing linkage failures. These problems may be reduced when the SuperNet itself stabilizes and as video equipment and peripherals mature and become more robust and user friendly, but the fact remains that technology failures will never go way completely.

Video Quality

During the site visits, participants often commented on the video quality of their conference. A general concern expressed by teachers and students alike was that they were not able to view all of the participants all the time, and that the images of the participants they could see were not clear. Students seemed less concerned with this aspect than teachers, who expressed significantly more concern. Indeed, the students noted problems, but they did not dwell on them. Nor did they evaluate the video quality in strongly negative terms. "*They have lots of people who sit off to the side that we never see*" commented one group of students. "*Sometimes we pan the camera around the class and we're like, 'Hey, we've never seen those people befor*e.'" Researchers observed that this type of experience, however, was typically confined to larger video-conferencing classes.

Teachers were less likely to gloss over video problems. Describing her inability to capture the entire class in one screen shot, one teacher told us: "*The camera is mounted at the front of the room and even if I pan as wide as possible, I still can't see all the students. Even when I can, I see, for instance, somebody doing something they're not supposed to, but I can't really see what's going on.*"

Teachers expressed concerns about the clarity of the images, and explained some implications. "*The students in the background, well that's exactly what they are – background. I visited* [the remote site], *and as I was walking through the halls a couple of students recognized me. I looked at them, and I thought 'I should probably recognize them since I've been teaching them for the last two or three months'* (laughs)." This experience also happened during a video-conferencing session with researchers. After researchers observed a video-conferencing class in session remotely, the teacher visited researchers at their site the following day. When introduced, researchers did not recognize this teacher in person.

This example illustrates how video clarity matters in video-conferencing classroom. It also demonstrates that care must be taken to adjust screens for color and contrast, and camera equipment set up for focus and lighting. Variations in picture quality from jurisdiction to jurisdiction were noted.

Researchers also observed use of remote control cameras during one point-to-point video-conferencing session. This allowed the teacher at the host site the ability to adjust the camera angle, zoom, and area of coverage of the remote site with a touch of a button. Combined with high-resolution projections from the remote site, it was evident this teacher was in a good position to see what was happening at the other site.

In most of the multi-point systems observed, images of all the participating classes shared screen space on one monitor in a format referred to as *split-screen mode.* At sites where there were three or four classes participating, individual images measured 6 x 6 to 8 x 8 inches in diameter. It was difficult to determine if students were present at a particular

site, and to distinguish students from equipment. One multi-site teacher noted: "*Originally, I was supposed to have one screen per group, and I would have been able to distinguish faces, which I can't on the split screen. I can't. I don't know who I'm talking to*." When asked if she would be willing to teach using video-conferencing, this teacher told us: "*Not if it's still split-screen. That's my only requirement*."

Problems with image quality, though cited as serious by teachers, did not seem to be insurmountable. Indeed, most teachers offered simple suggestions about using the existing equipment more effectively. Some jurisdictions had already purchased additional monitors and were working on a way to dedicate a separate 32" screen to each video-conferencing class. Some jurisdictions told us they were experimenting with different camera placements. Manipulation of the cameras was a simple suggestion offered by one group of students: "*If you zoom in on one person it looks quite decent. We can make out the faces of the students at the other school if we zoom in. You could copy words off paper if you zoomed right in*."

Some technological solutions are in use, however, that may address this concern. For example, in one division the cameras will zoom in on any participant who presses a 'question' button. This zoom function allows the teacher (and other video-conferencing participants) to clearly see the facial expressions of the questioner. Unfortunately, shyer students did not always appreciate this level of magnification. Indeed, in the classes observed, this feature was seldom used. Instead, students would ask a question verbally without pressing the question button, and the teacher would spontaneously respond. Students could be compelled to use this technology through the teachers' insistence on its use, and this would improve this component of individualized classroom interaction.

In summary, video-conferencing has been described in the literature as providing the visual feedback deemed critical to interaction and ambience setting of the classroom. Moreover, participants new to video-conferencing feel that they should be able to observe body language, notice and admonish disruptive and off-task behaviour, and function using video-conferencing technology in the same manner as they do in a traditional classroom setting. Researchers found that the current video-conferencing technology in place often does not meet these expectations. While video feedback and presence is greater than in audio-based systems, it is not the same as a "real classroom". Improvements in screen resolutions – especially when multiple sites are involved – are needed.

Audio Quality

Similar discussions arose concerning the sound quality of video-conferencing. Research has established that audio quality is more critical than video quality (Patrick, 1999), and this research was supported by participants, who were more forthcoming in their criticisms of audio quality.

In two jurisdictions, audio problems were minor or non-existent. In the other three jurisdictions, however, audio received low ratings: "*Out of 5 about a 2*," said one student making up his own metric. "*Really bad*," said another. "*There is days when it is good, but there are other days when it is just horrible*," added a third.

The principal concern participants cited was not being able to hear other participants. In some instances, researchers observed that students could not hear their teacher, typically when the teacher moved away from a single, stationary microphone. Most complaints, however, focused on not being able to hear fellow students. "*We can't really hear them that well*," one student offered, "*and I doubt they can hear us that well. They're always saying 'we didn't hear you' and 'say it louder.'*"

In one jurisdiction, the ability to 'hear' other participants did not necessarily mean that they understood them. Distortion, typically originating in small inexpensive speakers and audio anomalies such as echoes, reverberations, and "*that weird computer voice*", added to video-conferencing participants' frustration.

In another jurisdiction, students relayed that their video-conferencing system was not fully synchronous. "*There's a delay*," they said. "*I start to talk and the teacher starts talking and then we're both talking. Or I'll talk and it'll take the teacher a minute to react. It happens when we're watching movies, too. The lips are out of synch with the sound or sometimes the scene isn't the same, which really sucks*."

Participants addressed audio quality issues in several ways. One teacher mentioned: "*I talk a lot louder than I do in my regular classroom*." Another tactic observed that teachers tended to adopt to overcome deficiencies in video-conferencing audio quality was to repeat students' responses so that others could hear them. However, this tactic took valuable time and often slowed the lesson. Always having to repeat the questions and comments of a student resulted in numerous problems, and one teacher speculated that more microphones might help. "*That way, I wouldn't have to run around with the mic from student to student*." The same teacher also joked: "*Maybe we could hang mics from the ceiling, but I'm concerned that they would end up like piñatas*."

Variability of the audio performance in various video-conferencing settings highlights the differences in quality (and cost) of the audio equipment used in the five jurisdictions visited. Researchers made the observation that it was very possible to conduct relatively effective video-conferencing sessions with poor video so long as the audio is high quality – but the opposite situation of high video quality coupled with low quality audio was not tolerable.

There were a number of innovative strategies employed to improve audio quality in the video-conferencing classrooms. For example, FVSD installed high-end Gentner audio matrix mixers with echo cancellation combined with desktop microphones for each student to use. This audio configuration provided excellent results, however in order to activate their microphones, students were required to use the "push-to-talk" button. Teachers noticed a lack of student participation in this model, so the jurisdiction installed

ceiling microphones. Desktop area boundary microphones installed in many jurisdictions allowed for hands-free, always-on audio from remote sites. Desktop microphones picked up all audio input from a room however, including unwanted noise such as paper shuffling, fidgeting, etc. Ceiling microphones come with their own set of problems, however. They are located farther away from participants than desktop microphones, therefore requiring the gain on each microphone to be increased. The increase in gain also increases the amount of ambient noise picked up by the ceiling microphones. Ceiling microphones also pick up heating and air conditioning, projector fan, and speaker noise, etc.

The highest quality audio was achieved through increasing the number of microphones used in the video-conferencing room, and decreasing relative distance to participants from each microphone. An ideal solution (which was not observed in the K-12 environment, but is common in post-secondary institutions) is to have one microphone for each student that is always on. During site visits, the best quality audio performance observed occurred in small classrooms where two or three students shared a single desktop microphone, and muted the microphone when not in use.

Some schools were seen to mute remote sites during lab times and other private work times, which eliminated distracting background noises like paper shuffling. Taking this simple measure allowed students to concentrate on their assignments and interact with each other without triggering a microphone and creating distracting noise. Attracting the teacher's attention was not observed to be a problem in a remote video-conferencing class monitored by a teacher's aide.

Multi-Point Delivery

Video-conferencing involves teaching to more than one class at a time. Participants' comments focused on issues arising from this process are discussed below:

1. Synchronizing Schedules

One of the practical issues of multi-site video-conferencing is synchronization. Events and activities must occur at the same time across all sites, including starting and finishing classes (and the buzzers and bells that signal these events), holidays, and routine uses of the public address systems (such as the playing of the national anthem or morning prayers). Critical synchronization can be difficult to coordinate throughout a given jurisdiction, and many of the schools visited had not resolved these issues completely.

Joining a class that is already in session, listening to *Oh Canada* several times, or sitting through another school's announcements is frustrating for participants. One student related: "*It drives me bonkers. We hear all of their morning announcements, and we don't hear ours. Plus their class starts later and runs later than ours, so we have to wait for them to arrive and get settled, and we waste a quarter of the class.*" This student may have exaggerated the amount of time 'wasted', but the estimate was consistent with that of the teacher's, who said: "*You probably heard it this morning – four national anthems*

going off at the same time. It takes about 15-minutes by the time they're all done and I can begin."

2. Classroom Management

Once the participants are settled into the video-conferencing session, the next problem that can arise in the multi-site format pertains to classroom management. Maintaining an environment in which students can concentrate, stay on-task, and resist temptation to disrupt others can be difficult at a distance. Several students throughout all the jurisdictions appealed for a supervisor at their remote site. They recognized their inability to work independently, and they drew comparisons between unsupervised video-conferencing and correspondence study. *"I like having a teacher in the class, and I follow more closely when the teacher's here. When the teacher's not here, I don't get anything done; I pretty much just goof around the whole class because there's no one there to enforce it.*"

One of the questions that each group was asked was how much same-site discussion they engaged in. "*Discussion of what?"* laughed one group. "[The course material] *or something else? In a 60-minute class, I'd say there's about 40-minutes of talking, you know, everyone talking.*" Seeking to have participants expand upon their observations, researchers asked them about the proportion of talk that was on-topic: "*About 25- or 30-percent*" estimated one. "*It's like about 20-percent*" said another. When asked if this situation was typical, the students told us: "*Yesterday was kind of different because you and the principal were here. Usually there's a lot more*." This comment illustrated how the presence of observers influenced participants' behaviour. Moreover, these comments support the use of in-class supervision (i.e., teachers' aides) in remote video-conferencing classrooms.

3. Circulating Documents

Circulating documents among teachers and students across a jurisdiction can also lead to difficulties. Homework assignments need to be submitted and returned, new assignments need to be distributed, and paper-based tests need to make their way securely to and from teachers and students. Facsimile machines in each of the video-conferencing classrooms fulfill most of these functions, but not without issue. "*We have problems using the fax machine*," one group of students explained. "*One time at the beginning of the year we kept on faxing and faxing our assignments, but the teacher couldn't get them. It turns out we were sending it to another school, and we couldn't get marks for it*." This system also presented problems for some teachers who said they felt uncomfortable asking staff at other schools to be responsible for distributing their course material: "*When it comes to quizzes and exams, you can't fax them directly to the classroom, you have to fax it to a contact, and they have to be distributed at a certain time. I wish there was somehow a way around that*." Another teacher explained: "*I have to ask someone else to do things that I would normally do.*" This situation creates new duties for various staff across the jurisdiction. Researchers concluded that there is a need for greater logistical coordination and synchronization.

4. Remote/ Host site Synchronization
Ensuring that students have clear course outline and deadline expectations takes on amplified importance at the remote sites. Without impromptu cues that are typically easily recognizable in a conventional classroom setting, students can be taken by surprise. One student told us, "*Sometimes we come to class and the teachers says, 'Ok, hand in your assignments' and we're like, 'what?' It's also hard on tests because it's not posted anywhere. She'll tell us once and then all of a sudden there's a test.*"

5. Divided Attention
Aside from the issues presented thus far (document circulation, class management, and synchronization), other issues arise in the multi-point configuration: the teacher's attention is divided and the monitor on which the students' images are presented is split.

Anytime an instructor-student ratio goes above 1:1, the teacher's attention is divided, regardless of the environment. In a multi-site video-conferencing, a teacher's attention is divided not just among several students, but among several classes.

For students, the problem can be summoning remote-site teachers or sharing them with students who are struggling. Onestudent related: "*Sometimes* [teachers] *don't answer you. It happens in our regular class too, but it is worse when the teacher is at another site. If there's someone at another site who is having problems, they get all the attention. It would be better if there was one teacher for each class. Then they'd only have one class to focus on.*" Another student added some drama and hyperbole to her description: "*It takes awhile if you have your hand up because the teacher's looking at the screen most of the time. You half to hold your hand up for a long time, and all the blood rushes down and your hand gets all numb. It's horrible.*"

Teachers are aware of this issue and stated that they try not to let it happen. "*I was warned of the danger of focusing entirely on the class here and forgetting about the one on the screen*," said one. "*For the first month and a half, I found it was exactly the opposite. I spent most of my time focusing on the remote site and neglected the students here. It seemed like the students here were just sitting there like they were watching TV.*" "*Yeah,*" responded one group of students, "*the teacher was talking to the other class, and we were just listening to the teacher talking to them.*" Another teacher described her method for overcoming this problem: "*I'm very conscious when I'm asking them questions and asking them to respond – I'll direct two questions to one site, two to another, and two to a third.*" Another concern expressed by the teachers in the study is in their ability to take attendance when the video does not cover entire classrooms.

In the examples of video-conferencing observed, images of the various classes share screen space on one monitor. These images are small and the amount of visual information available was judged as insufficient. "*It's simply too small to be of much use*," was one teacher's assessment. "*I can't distinguish facial features on the split screen. I don't know who I'm talking to. I find myself addressing the kids by the name of their school rather than by their individual names.*" Another teacher described to us

some of the implications of this issue: "*As a teacher, I rely on all sorts of cues from my students. When I start to see fidgeting and it's spreading throughout the class, or glassy eyes, I know I've been talking too long, and it's time to switch activities. I know when what I'm doing isn't working, and when I need to find another way to try and get it across to them. I'm not picking up on that stuff in this format.*"

Other problems observed included teachers' inability to coax reluctant students into participation, inability to use presentation equipment effectively, and inability to develop a working relationship with their students. This observation should not reflect badly on video-conferencing teachers, however. "*I have a very difficult time knowing who hides from me,*" one teacher told us. "*In a regular classroom, I know who my hiders are. I know which kids won't put up their hand but are understanding everything that goes on, and which kids won't put up there hand but don't know what's going on. We all have our kids that want to answer every question, and in this format those kids tend to dominate. With the small screen, I don't have the ability to distinguish between those groups and to prevent that.*"

6. Building Relationships

Their inability to develop effective working relationships with their students frustrated the video-conferencing teachers. These teachers described the differences they perceived between the students that were in their classrooms and the students that were at their remote sites.

"*The kids that are in my room, I can tap them on the shoulder, or I see them out in the community and talk with them. That makes a big difference. I don't feel like I have that with the other kids at the remote sites. We did meet once when we did a lab together, but it's not the same. We kind of lose the sense of togetherness that develops when there's only one group. A lot of time, I feel like I'm trying to be not too friendly with the students at my site because I don't want the other students to feel bad. I know the kids at my site a lot better than the kids at the remote sites. That's probably the one aspect of teaching on video-conferencing that I'm missing. If I was there with them, we would have a lot more togetherness. That's my feeling.*"

These comments are illustrative of the lack of equivalency that can be felt between video-conferencing and traditional classroom instruction. Indeed, there are barriers to conducting effective video-conferencing events, but these barriers can be overcome with the adoption of good quality technology, and perhaps most importantly, with pedagogical approaches that recognize and exploit the opportunities afforded by video-conferencing technology.

Interaction

Video-conferencing has potential as a technology that affords a rich communicative repertoire essential for effective teaching and learning. Rural and remote jurisdictions in particular are anticipating that video-conferencing will be an improvement over the correspondence and audio-conference technologies they have been using. Many

participants who had experience with these older technologies agreed was the case. Others were not as convinced, however. This section discusses the participants' perceptions of video-conferencing interaction.

Students talked about interacting with students in their classes and with students at the remote sites. The primary concern raised by teachers and students was the relative lack of one-to-one interaction with students at the remote sites. Participants identified several barriers.

In some circumstances, there were simply too many students engaged across multiple sites. In large video-conferencing classes, students said that they could not always squeeze their questions in, or they did not want to impose on others' time. Some did not feel there was time for an adequate answer, and others were not comfortable asking questions in front of an audience broadcast across several sites. These problems are not dissimilar to those experienced in a face-to-face classroom; however the challenges of turn taking, limited audio and video quality in multi-point classrooms, and the lack of familiarity and resulting comfort in this context exacerbated these common educational problems.

Reseachers observed that students tried to work around this problem in several ways. They stayed after class to ask questions, but this was not always successful because in some jurisdictions, the video-conferencing system shuts down automatically once the class is over. Typically, the students or the teacher must proceed to their next class, or another class is waiting to use the school's video-conferencing system.

Some students said that they had tried to contact their teacher via telephone or email. Some jurisdictions, however, discourage students from phoning their teachers, and others did not allow their students to have email accounts because permissions have been abused in the past. Several students suggested that a synchronous chat system would help. Many jurisdictions have synchronous chat systems as part of their video-conferencing (i.e., for live troubleshooting between sites), but few jurisdictions allow students to use them as a forum to ask questions during class.

One-on-one interaction between the instructor and students at the remote sites was a concern for each of the teachers interviewed and some of the students. Participants cited two reasons for wanting more one-to-one interaction. Teachers felt it would allow them to develop working relationships with their students and make the educational experience more personal. This problem was discussed in a previous section. On the other hand, students cited their desire for increased one-to-one interaction when they encountered concepts they did not understand and wanted the teacher to expand upon. "*I need one-on-one time with my teachers*," one student explained. "*There's some stuff they teach to the whole group that I don't fully understand, and I need to ask questions. But, there's enough time to get the full answer*."

Another form of interaction that presented a concern was class discussion. A teacher in one division shared some of the difficulties: "*This could just be the way we have things*

set up, but one of the problems I've had is getting discussion going back and forth. Maybe if we had the microphones placed so that when the students are speaking the other group could hear them. Right now, I find that the groups just end up talking among themselves as opposed to talking back and forth." Students noticed a difference between discussions in video-conferencing and discussions in a conventional classroom: "*It's a lot harder in video-conferencing because* [this course] *is a huge debating thing. When you're in a classroom and you don't have a monitor or speakers or anything, it's just you and your class. Everybody can exchange what they're thinking, but with this you have to wait until the other person's done talking or there's static and they can't hear you and you have to repeat yourself*." This student's explanation confirms some of the students' speculations about training to use the technology effectively and schools need to find new ways of performing multiple types of interaction via video-conferencing.

Student Engagement

School personnel interviewed spoke of "engagement" as an observable benefit that can be derived from video-conferencing. Therefore, as researchers listened to their audiotapes and reviewed their videotapes of the site visits and interviews, they looked for evidence of student "engagement".

Engagement has been constructed in three ways in the literature. Pintrich and colleagues (1990; 1992) conducted several studies on *cognitive engagement*, in which they examined the mental effort that students are expending to integrate new material with previous knowledge. Fisher (1980) writes about *affective engagement*, which he defines as the level of students' investments in, and emotional reactions to, learning tasks. Chapman (2003) is concerned with *behavioral engagement*, which she characterizes as the extent to which students are making active responses to their learning tasks.

Students and teachers throughout the jurisdictions that were interviewed commented on these issues. After observing several video-conferencing events and speaking to groups of students in a dozen schools, researchers were left with the impression that there is little about video-conferencing technology itself that is inherently engaging. Instead, engagement was related to factors such as (a) teacher's physical co-presence in the video-conferencing room, (b) students' intrinsic interest in the curriculum, (c) learning activities that were captivating, (d) audio and video equipment that was effective and reliable, and (e) students' ownership and commitment to success.

A factor that was present in a class that demonstrated a convincing level of engagement was that the curriculum was optional rather than core, and the students were intrinsically interested in learning the content. When students were asked what they would do if the course was not offered through video-conferencing, they replied they would find a way to learn it: "*I probably would ask my parents to teach me*," replied one. "*Take it by correspondence*" said a second. "*I'd find some way to take it*" insisted another. The course they were taking had, in fact, been developed in the video-conferencing format because of the strong demand from students throughout the division. In other conferences, the intrinsic interest in the curriculum was missing. When students were

asked why they had enrolled in their video-conferencing course, they usually replied that they needed the course to graduate, they needed to fill a gap in their timetable, or they just needed some credits and the video-conferencing course would do. Among these extrinsically motivated students, there was less evidence of engagement.

Another factor influencing student engagement was the type of learning activities in which they participated. Students demonstrating engagement adapted their environment to enact small group collaborative activities. Unlike their counterparts who muted their microphones and chatted, these students muted the microphone so they could engage in productive "side-talk" – on-topic discussions that arise extemporaneously from a genuine involvement in the content. "*The video-conference classes have definite advantages*," explained one student. "*We can mute our mic and help each other out a bit more than we do in a traditional class*." The number of students in their video-conferencing classes and the arrangement of the room led some to assess these settings as *better* than conventional classrooms: "*I think this is just as good as a regular class, if not better. We have groups that we can talk to immediately, and we don't have to move our desks around and everything*." Another added: "*I like it more. Even though the teacher isn't there, I can still ask questions of the other students. The classes are smaller, and I have more fun.*"

In some jurisdictions, the ability to engage in captivating activities was hampered by the quality and effectiveness of the video-conferencing equipment. Attempts to coordinate cross-site discussions, paired activities, and interactive games were foiled by poor audio or video. When these activities broke down, the teachers reverted to didactic methods of teaching, which the systems supported adequately. "*I play games at least once a week in every class that I teach face-to-face*," one teacher reported, "*but I can't play those games in this format.*" Another explained: "*There has been a couple of times when we tried to read together as a class, but I found that it wasn't working well. We spent too much time trying to hear each other. So, we said 'we'll do our thing and you do yours and we'll meet back together in 20-minutes.'*"

Finally, the enrichment activities that were observed were planned, orchestrated, facilitated, and technically driven by the students themselves. Typically a group of older students enrolled in a video-conferencing CTS module were involved with organizing and presenting an enrichment activity for their fellow students. This level of ownership of the video-conferencing event translated into high levels of commitment and engagement. The topic of the video-conferencing event was also selected with student input and therefore generally held intrinsic interest for students. Student facilitators learned the skills of event production, camera operation and editing, hosting, and organizing prior and post production activities. These are important career skills for a media-rich context in which they will live and work.

In summary, **engagement is a variable of the *context,* not of the technology**. The same technology can be used very effectively to support and encourage student engagement or to repress and allow disengaged behaviour and attitudes. Learners can be engaged in distance education courses distributed over multiple sites, but achieving such engagement

does not come easily. Teachers and students must develop and support learning activities that engage and motivate them. Observers found that the challenge of new teaching environments tended to cause teachers to revert to simple and familiar behaviors – often associated with lecturing and questioning. The challenge is to create and adapt video-conferencing and other distance education technologies such that teachers can become confident, competent, and comfortable users – such that they can push and explore more complicated, constructive forms of teaching.

Comparisons to Other Education Delivery Modes

In the rural and remote school jurisdictions, participants have had experiences with various modes of education. When they talked about their video-conferencing experience, they often compared it to their experiences in conventional classrooms and in correspondence courses.

With few exceptions, teachers and students thought that video-conferencing was better than correspondence study, but not as good as the conventional classroom. One factor explained much of their assessment: their ability to interact with the teacher and other students. Correspondence study was regarded as less interactive than video-conferencing because it offered little in the way of timely, lengthy explanations to students who encountered difficulties. Students' perception of correspondence education was that there was no one-on-one interaction with a teacher, and no one was available to help them when they needed it. "*You get no help,*" one student said. "*If you get in trouble, you'll be lucky if you can track down a teacher that knows what you're doing*." One teacher who was supervising a correspondence course provided another perspective: "*Students take correspondence classes, and I don't see the students. I see them when they finish an assignment, but that's it.*"

Along with the lack of guidance and coaching, many students felt that they did not have the self-discipline that correspondence study demanded. One student summed up the feelings of many by saying: "*Correspondence was* [not a good learning experience]. *I can't make myself do the work. I won't sit myself down and do it.*" Researchers spoke to many students who were currently registered in a correspondence course, which they had not begun or were far behind schedule. One student told us: "*My mom made me take this course through video-conferencing. She didn't want me to do correspondence unless I absolutely had to.*" When asked in January how her correspondence course was progressing, she reported: "*I haven't finished it. I started last June. I'm not sure how long we have to finish, I think it's up to a year or something. It's hard*." Another agreed: "Y*eah, I'm doing Math 25 by correspondence right now. That was a mistake. I started last year and I'm just deciding to do it now*."

Students found more support and structure in their video-conferencing classes than through correspondence, but not as much as they did in their conventional classrooms.

After voicing concerns about the lack of interaction, one teacher offered that video-conferencing also had advantages over classroom instruction: "*I try to keep it as similar*

to a regular classroom as possible, but with a lot more jazz as far as the technology goes – like being able to quickly find little video clips on the web to show them what I'm talking about, rather than showing them still pictures. That's the one part of technology that I just love, to be able to bring the Internet right there for them instead of saying go to this website and find it and wasting time finding it. In this case you can just bring it right to them."

It is interesting to note the excitement expressed by the teacher above when she was able to access the web and share results in real time with her students. This is a capacity not of video-conferencing, but rather of the capacity to share a workspace with distributed groups of students, in this instance supported via the networked SMARTboard.

Section 5: Three Applications of Video-Conferencing

Video-conferencing is being used by the five jurisdictions studied for three types of activity: administration and professional development; learning enhancement; and, distance education. Researchers found general satisfaction and evidence that video-conferencing adds significant value to all three activities. This study concluded that the use of video-conferencing for administrative, professional development, and enrichment uses are useful and should be continued.

Administrative and Professional Development Applications

Use of video-conferencing technologies for administration and professional development provides a sound rationale for the purchase and support of video-conferencing technologies in Alberta schools. Each division studied in this project used video-conferencing for administrative and PD delivery. These activities range from regular principal meetings, consultations with education specialists, board, teacher, and professional association meetings, to job interviews.

The "business case" is strong for school jurisdictions to increase the use of video-conferencing technology for administration and PD. Lower costs related to travel expenses, and saving time associated with extensive and sometimes dangerous travel are compelling reasons to expand the use of this application.

The greatest barrier to extensive use of video-conferencing for administration and PD is the availability and cost of equipment and rooms. For this reason, researchers recommended that schools consider purchasing a mix of video-conferencing equipment including smaller, less expensive and more flexible desktop units for individual and small group meetings. These smaller units are PC-based, very flexible, and can be used by one or two participants in regional offices, homes, or schools. Fortunately, these smaller H.323 desktop units use the same protocols as larger room sized units, so connectivity both within and across school jurisdictions should not be problematic – especially once the SuperNet is fully deployed and bandwidth increases.

Video-conferencing equipment was also used to good effect for PD activities. The video-conferencing experience facilitated the creation of social presence and immediacy among participants and added a synchronous component to pace professional development sequences. To date, most video-conferenced PD activity has related to the use of the video-conferencing video-conferencing equipment itself and the pedagogies required for effective teaching in video-conferencing environments. There is no reason, however, why video-conferencing cannot be used to deliver a wider variety of PD activities aimed at benefiting all staff and school personnel. Indeed, PD is a key factor in retaining qualified staff and upgrading staff skills in all schools, especially those located in rural jurisdictions (Manuel, 2003). In an era marked by rapid change, PD is essential to effective organization performance. Ever increasing and changing responsibilities for local school-based administration (i.e., changes in curriculum and regulations, adoption

of new teaching technologies and pedagogy, increasing sophistication of school and jurisdiction accounting and management software) are all solid arguments for the design of PD opportunities based on video-conferencing delivery. This technology, however, must be user friendly. The video-conferencing systems studied and overviewed in this report were observed to be user friendly and participants, with little or no formal training, were able to successfully engage in PD activities using video-conferencing technologies.

Video-conferencing worked well when used in combination with other technologies in a PD model. All teachers within the inquiry mentorship piece of the project successfully created an inquiry-based task/problem for their students. The success of these tasks was in a large part due to their ability to work online using a collaborative online learning environment for teachers and e-mail, and to confer with each other using telephone. Using video-conferencing to connect with at least one of the teachers was a definite challenge, as connectivity to sites outside the school jurisdiction were extremely difficult; this, however, was well worth the effort. Teachers' ability to connect through video-conferencing technology helped them to form relationships, which created a strong connection that resulted in all teachers and their mentors wanting to continue to work together. It also provided them with the motivation and deep desire to want to persist in trying to connect using video-conferencing technology. A spirit of professional collaboration and collegial accountability resulted through the work that the teachers and mentors undertook.

Increasing opportunities for school personnel to engage in life-long learning, particularly post-secondary accredited courses and programs, is clearly relevant for staff and faculty who need to upgrade their skills and knowledge. Currently, use of video-conferencing for this purpose is minimal. At this time, video-conferencing delivery is not a common educational delivery mechanism used by Alberta's post-secondary institutions for distance delivery of either stand-alone graduate or undergraduate courses. This may be attributed to historically higher costs associated with video-conferencing and thus, its limited adoption. However, as it becomes available in the schools and increasingly in homes and businesses, especially coupled with SuperNet access, video-conferencing could enable universities to create region-specific cohorts that allow students to come together in one or more locations to participate in classes or workshops. Video-conferencing could also allow schools and PD consortia to deliver PD workshops and courses in the same manner. The U of L provides an example of this in their use of video-conferencing to offer graduate courses in education to teachers in the Peace River School District.

Course Enhancement

This research study found that video-conferencing was particularly effective for course enhancement. Observations of enrichment activities at EPS and other jurisdictions led researchers to concur with most of the literature in this area, which documents the value added educational delivery using video-conferencing for course enhancement activities (see the literature review at http://VCAlberta.ca).

Benefits of these enrichment activities include:

- Enhanced learner motivation;
- Increased collaboration between schools;
- Opportunity to develop new pedagogies and learning activities;
- Opportunity to link school and communities;
- Increase access to outside expertise;
- Development of web-based communication and presentation skills; and,
- Development and support of learning communities at all levels.

Participating with remote students or experts provides an "outsider perspective" that has long been associated with effective learning (Arnold, Cayley, & Griffith, 2005). The experiences the research team had while mentoring teachers to develop inquiry-based models of teaching and learning illustrated the value of video-conferencing technology in not only creating a means to interact with outside experts and distributed students, but also as a catalyst to stimulate participants' involvement and excitement in the learning experience.

In some schools visited, the students themselves were creating the video-conferencing experiences. These designs empowered students to present, direct, and produce interactive activities using the technologies – activities that helped students develop important technological and communication skills.

The greatest challenge, however, in the creation of enrichment activities is to provide evidence (beyond participants' perceptions) that the activity is directly and positively related to enhanced learning outcomes. In an era marked by calls for "evidence-based" research aimed at determining the value of all school activity (Slavin, 2002) it is critical that the course enhancement applications using video-conferencing technology be thoroughly evaluated. Such evaluation may be challenging in video-conferencing educational contexts, however, because outcomes may be more directly related to positive affective outcomes – such as improvements in student attitude – than performance that can measured on standardized tests. Nonetheless, these and other outcomes must be rigorously measured using a variety of investigative techniques. Currently there is little evidence available that links enhancement activities directly to improvements in learning outcomes. So, while the case can be made for the use of video-conferencing technology for enrichment activities, this case has yet to be made conclusively. Further research focusing directly on measuring outcomes of video-conferencing enhancement activities is needed.

A final compelling application for video-conferencing is its ability to provide remote consultations, connecting with experts of another kind. For example, two school jurisdictions in this study used their video-conferencing systems for diagnosis and consultations with speech therapists, psychologists, and other experts. Access to this caliber of professional expertise is typically restricted in rural school jurisdictions; moreover, it is expensive to bring in such expertise for face-to-face consultations, or for

students and their parents to travel to the expert. Video-conferencing technology makes such consultations cost effective and affordable. PRSD's pilot video-conferencing project involving a speech therapist's diagnosis of a remote student is one such example of this use. This project will be followed in more detail in the 2005-06 school year when SuperNet becomes fully operational in the jurisdiction.

Distance Delivery

The argument for delivering courses at a distance using video-conferencing alone is less compelling. In some districts, video-conferencing is perceived by teachers, administrators, students, and the larger community as a means to recreate the classroom experience at a distance – an export function that requires minimal change in pedagogy and classroom behavior. As one teacher explained: "*I put on a façade for the students like everything's OK, and tried not to treat it any differently that a regular classroom.*" Early findings, however, indicate that the video-conferencing experience is inherently different from classroom teaching and, in most cases, more challenging for teachers and students. "*I felt quite jittery the first day. It probably took me a month to be comfortable in there*", said another teacher. The researchers' experience as distance educators also leads them to argue that video-conferencing can be used as only one tool in a suite of many distance education technologies.

The distance learning environment is undergoing rapid and fundamental changes due rapid increases in bandwidth (i.e., SuperNet), coupled with a growing array of rich web-based teaching/ learning technologies available to educators. These advances create an environment in which many different technologies can be used to create educational benefit. None of the available technologies offers students a rich learning context on its own, and each suffers limitations. However, by mixing and blending technologies (i.e., synchronous and asynchronous) a truly rich learning environment can be developed.

As a synchronous technology, video-conferencing has its strengths and weaknesses. Its strength lies in the quality of voice and images exchanged. Its relative weakness lies in high costs involved to purchase quality technology, technical and pedagogical challenges associated with multi-point delivery, and limited capacity to easily record and archive sessions for reuse at a later date. Although it is relatively easy to record a video-conferencing session with a videocassette recorder, the archiving and distribution of this physical medium creates additional tasks for teachers or support staff. Finally, video-conferencing by itself does not involve various forms of asynchronous interactions such as threaded text discussion, blogs, Wikis, learning objects, virtual tools, collaborative work spaces, and other web-based teaching and learning technologies. Researchers conducting this study believe the most effective approach to educational technology adoption and use is to create rich mediated learning environments that employ a blend of interactive and non-interactive, synchronous and asynchronous, independent and collaborative learning technologies. They argue that video-conferencing alone cannot create a rich enough environment for distance education provision, and therefore should be supplemented with web-based technologies to construct optimal learning contexts.

Data gathered from discussions with teachers, administrators, and students indicate that exclusively asynchronous delivery using various forms of individualized correspondence or web-based delivery systems are not likely to meet the majority of learner needs (see also Moore & Kearsley,1996 p. 160-164). The challenges of student motivation, support, rapid feedback, and absence of learning community often result in higher student dropout and non-completion rates than classroom-based education. A blend of learning technologies, therefore, should include some form of synchronous learning environment designed to foster student cohorts, and provide high levels of both student-student and student-teacher interaction and feedback. However, because students can – and do – miss class due to bad weather or illness for example, learning interactions should be easily recordable and archived for later use at home, work, or a special environment such as those found in hotels or hospitals. Second, this blend should allow for extensive use of multimedia learning objects such as those developed, keyed to the curriculum, and made available by Alberta Education in their LearnAlberta.ca learning object repository (http://www.learnalberta.ca/). Third, the environment should allow students to create, store, and display content created both individually and in groups. Tools such as Wikis, blogs, document managers, web annotation, and other learning technologies support this collaborative construction and document management capacity. Fourth, the learning environment should allow and support a variety of types of synchronous and asynchronous student-teacher interactions and feedback loops, such as the capacity to poll students to determine their understanding or attention to a particular topic. Fifth, the ideal learning context should allow student-student interaction in a variety of formats (i.e., text, voice, and video) and support both synchronous and asynchronous formats. Sixth, an ideal learning environment provides tools to create, share, annotate and critique text, and other multimedia documents. Finally an ideal environment allows for flexible scheduling so that individuals or small groups can participate using a variety of tools and learning group configurations.

Blended Learning Environments

In most cases, the video-conferencing tools alone observed in this study did not provide a complete array of teaching and learning tools. Some settings observed provided examples where another collection of tools (notably whiteboard, web surfing, and presentation graphics) were added to the video-conferencing environment. These additions were greatly appreciated by both students and teachers, and used extensively in some classes. Researchers did not observe in their site visits, however, any recording technology being used, student sharing of software presentations, application sharing, break-out sessions or group discussions, or automated class polling**.**

The above discussion suggests that video-conferencing alone provides students a somewhat limited learning environment, one that should be augmented with a variety of web-based technologies to provide optimal distance education experiences and learning outcomes. To date there appears to be, at best, limited success in creating and sustaining online communities of practice where participants are motivated to initiate and sustain lively conversation, joint action, and critique.

As a technological basis for creating an enriched environment, the use of web-conferencing tools currently available may be useful. These technologically enabled learning environments provide graphic-based presentations, voice and text chatting, whiteboard, calculators, application sharing, recording, quizzing and polling, web safaris, and even limited webcam interaction. In this context, video-conferencing can be used to enhance the basic web-enabled teaching/ learning environment. Video-conferencing enhancements also need not be scheduled every day, but instead used for special events such as guest speakers, debates, personal introductions, and other enrichment activities. In other words, adopting a blended learning environment – much of which is based on lower cost technologies – could lower or eliminate altogether jurisdictions' current need to expand their room-sized video-conferencing capacity.

Web-conferencing technologies are designed for a single student operating from their own networked computer. Such blended learning configurations therefore might consist of computer lab(s), a set of computers in the library, and/or other clusters of single user machines at home or at school. Access via wireless laptops or other portable devices provide students and teachers with greater flexibility. Using a blend of video-conferencing and webconferencing technologies – rather than using video-conferencing alone – allows for a more flexible teaching/ learning scenario wherein single or small groups of students can work together at home or school, and participate using an information-rich set of the learning activities. In other words, high levels of flexibility (i.e., blended learning) are necessary to overcome current scheduling problems, lack of video-conferencing equipment, higher costs associated with upgrading video-conferencing equipment, and "bleeding edge" redundancy currently faced in four jurisdictions' distance education programs. Finally, students introduced to learning contexts using blended-learning technologies today are provided with a foundation upon which to support their future learning experiences (i.e., a bridge to most online/ distance postsecondary courses offered in Alberta).

The final argument in favor of augmenting video-conferencing with webconferencing for distance education relates to the underpinning pedagogical model that conditions use of each technology. During the inquiry mentorship process, it became very clear in two of the cases that the work between the students and teachers could have benefited from creating blended technology learning environments. Using multiple tools, such as a learning management system, blogs, webconferencing, online community, etc., could have helped the teachers and students connect with each other in ways that video-conferencing alone could not support.

Video-conferencing technology, when combined with resources such as a collaborative online learning environment for teachers, subject websites, and e-mail, was successful in creating a robust PD mentoring environment. It would appear that adding video-conferencing might hold possibilities to supplement or replace face-to-face mentoring. This is a significant finding for the development of effective online communities of practice with a synchronous component.

It was beyond the mandate of this study to examine use of blended technology learning environments, however. In the researchers' recommendation to adopt blended technology learning environment models, it is assumed that students have access to standard web tools such as email, instant messaging, and browsing, as well as access to adequate student to computer ratios. Such environments are in existence across Alberta, and include many virtual schools. However, there has been little use or testing of webconferencing systems in classroom-based environments. As such, it is recommended that future evaluation studies on use of video-conferencing technologies in K-12 education be compared to blended technology learning and face-to-face classroom environments to determine video-conferencing's "real costs" versus "real educational benefits".

Researchers advised caution in the overreliance of video-conferencing as the primary vehicle for distance education delivery. Rich combinations of delivery environments are available and should be used to deliver distance education programming. While video-conferencing technology can work as the primary delivery technology, and examples of its effective use by highly skilled teachers are out there, video-conferencing is not a rich educational media by itself. Moreover, this study pointed out that video-conferencing requires high levels of commitment, funding, and support. With the arrival of the SuperNet and the ever widening array of lower-cost web-based learning technologies available, video-conferencing has been demonstrated to be effective as an enhancement component that adds synchronicity to a blended learning environment. Web-based technologies used in concert with video-conferencing can be used to develop quality distance education experiences.

Promising Practices and Recommendations

The following should be considered as "emerging promising practices", since their development in the field is relatively new and such practices are expected to evolve as jurisdictions continue to use the technology for multiple applications.

Promising Practices

1. **Professional Development**

   Change in one component of a system forces change in all other related components. Video-conferencing allows – and in some cases mandates – change in practice and policy. To ensure that such change works to improve learning and cost effectiveness, staff and students should be given the opportunity and incentive to participate in maximizing the benefits and minimizing negative repercussions from this change. Education PD systems must address the unique needs of both novice and experienced teachers. Hands-on use of the video-conferencing technology within and across divisions is encouraged, so that teachers can increase their skills in teaching in video-conferencing environments.

2. Student Empowerment through Operation with the Technology
Allocating responsibility to students to configure, troubleshoot, produce, and operate the video-conferencing equipment has many advantages, not only for the teachers, but for all participants. The development of CTS modules or locally developed courses in which video-conferencing operation, direction, and production are learning activities were observed as a means to empower students and equip them with new networking skills.

3. Technical Support
Technical support is a critical factor in successful video-conferencing activities for administrative, distance education, and enrichment activities. The best support observed included capacity for remote diagnosis of video-conferencing equipment, including capacity to monitor all technology and to re-boot and re-configure equipment remotely. There is opportunity for cost effective sharing of this type of technical support through collaboration among school divisions. Best practice includes capacity for emergency backup via redundant video equipment or more cost effectively by audio linkage (as supplied through commercial telecom vendors, or through existing jurisdiction-owned telecommunications switches).

4. Developing New Pedagogies
New tools often create opportunity for changes in practice. Video-conferencing and other networked tools can be very effective in creating constructivist learning scenarios in which students use the tools to create their own solutions to curricular problems. Students were observed to be more engaged in active learning when new instructional designs, such as inquiry-based learning, were employed.

5. Enhancing Delivery Capacity
In each of the jurisdictions observed, the demand for video-conferencing classrooms has grown, in some instances beyond the capacity currently available. Some jurisdictions have purchased smaller, desktop video-conferencing units for use in offices, staff rooms, etc., as a cost effective means to increase video-conferencing capacity. Such systems are very functional for individual and small groups of teacher and students and can easily connect to larger systems.

6. Mentoring to Support a Pedagogy of Inquiry
Video-conferencing technology, along with additional resources such as online communities, subject specific websites, and e-mail, are very successful in creating a robust mentoring environment supporting an evolving pedagogy of inquiry. This is significant for the development of effective online communities of practice. Adding video-conferencing to this mix of enabling technologies holds possibilities to supplement or replace face-to-face mentoring.

7. Enhanced Audio
Audio is the most important aspect of any video-conferencing event. Audio quality at each site varied significantly. Desktop area boundary microphones were successful

for small groups of students. Ceiling microphones seemed to create problems, however, with too much background noise added to the conference. Lapel or dedicated instructor microphones were most effective for transmitting uninterrupted audio from the teacher. The best audio solution observed included dedicated desk mounted microphones for one to three students, and wireless lapel microphones for teachers.

8. Site Visits by Teachers to Remote Classroom

Teacher visits to remote classrooms have long been used in distance education to support the development of quality student-teacher relationships. Such visits in this study were enjoyed by both teachers and students, and helped reduce the sense of isolation experienced by both. Best practice will likely include teacher visits to remote distance education sites early in the course to help build rapport.

9. Face-to-face Lab Days

Face-to-face labs allow learners in the same class to socialize and collaborate. In addition to teacher visits to remote sites, there is value in gathering all students in a common location. These activities can be used to provide access to labs or other technology, to learning resources not available locally, or to engage in cooperative or collaborative activities. Students noted that when these activities did take place, they were better able and more interested in communicating with other students. Opportunities to meet face-to-face is a strong incentive for student participation in all aspects of the course and program and therefore face-to-face class meetings are a component of quality courses.

10. Central Coordination

Video-conferencing, by definition and actual practice, is not a single, stand alone school activity. Thus, video-conferencing is challenging to support in school systems that are becoming more decentralized and focusing on school-based decision-making and budget allocation. There are numerous issues related to scheduling, school bus coordination, and PD for teachers, policy development relating to incentives for teachers, programming decisions, and equipment purchases that are best coordinated or decreed from a centralized office perspective. All schools jurisdictions in this study were are able to devote at least part-time division level administrative support to their programs and all argued that such support is critical.

11. Incentives

Distance education teaching in a video-conferencing context (especially when multiple sites are involved) requires more preparation than normal classroom teaching. Some school divisions have developed incentives such as course release, equipment allocations, or class aides that encourage teachers to make the extra effort involved. The best incentives are customized to the unique needs of individual teachers and systems, and thus will be different in different contexts.

12. Secure Connectivity Beyond a Single Jurisdiction

Administration, PD, and enhancement models of video-conferencing, all reach

maximum effectiveness when connectivity is supported to locations anywhere in the world. Such seamless connectivity that spans secure firewalled systems, at present, is not possible in most Alberta schools, however. Further study and development is needed prior to a standards recommendation from Alberta Education on an appropriate solution to this problem.

13. Continuous Research and Evaluation
This study of early adopters of video-conferencing in five school divisions points to the need for ongoing description and evaluation of video-conferencing applications. The technical and pedagogical context related to video-conferencing is changing rapidly and requires ongoing effort to insure that schools are able to take advantage of developments and best practices as they evolve.

14. Blended Learning for Distance Education
Delivery of complete courses and programs at a distance benefits from appropriate mixture of synchronous, asynchronous, text, video, and audio delivery to maximize motivation and learning effectiveness. Increasing media mix, however, usually increases costs. Thus, further research is needed to determine optimal mix of video-conferencing with other synchronous and asynchronous technologies.

Research Team Recommendations

Recommendations to Teachers:

- Investigate and develop instructional designs and learning activities that focus on providing space and motivation for students to work individually and collaboratively to create and share their own understandings of learning content using video-conferencing and other information and communications technologies.

- Participate online and whenever possible face-to-face in learning networks to share ideas of successful teaching and to support each other.

- Increase personal competency with video-conferencing and other digital technologies by exploiting the professional development opportunities and self-study provided by the technologies themselves to enhance personal productivity in performing instructional, professional and administrative tasks.

- Integrate other media use into lessons such that learners are able to acquire the skills of searching, personalizing, and manipulating information from many sources to construct their own knowledge.

- Develop blended learning opportunities for students and yourselves whereby face-to-face encounters among participants are blended with video-conferencing and online learning opportunities.

- Develop activities whereby students learn to use and control the video-conferencing technology so as to co-create their own learning experiences.

Recommendations to District and School level Administrators:

- Provide central coordination, policy development, and support for distance education enrichment and administrative applications of networked technologies, including video-conferencing.

- Provide opportunities for formal training and informal networking among teachers who are using video-conferencing technologies.

- Ensure that technical support is available, in real time, to teachers who are dependent upon communications technology to support active learning in their classes.

- Develop policies so that teachers who participate in distance education programming are supported in the efforts involved in effectively teaching in distributed contexts.

- Develop cost effective ways to provide effective supervision and support for students in remote video-conferencing classrooms. These will likely include designs such as use of teacher aides, on-call support from administrative or other teaching staff, construction of remote video-conferencing rooms with direct observation by school staff, and other strategies to provide assistance to students and the remote teacher in a timely fashion.

- Maximize the capacity of the SuperNet to transmit documents in any medium and to support document exchange between and among students and teachers. Utilize the capacity of available technologies to make this task as seamless and easy as distributing materials in a face-to-face classroom.

- Ensure that accounting procedures are in place to determine the real cost of all instructional programs, especially those that make use of video-conferencing technology.

Recommendations to Technicians:

- To support seamless connection of video-conferencing technology with users around the world, actively follow and participate in efforts to create means whereby local VPNs, can connect with other SuperNet VPNs, CA*net 4, and the commercial Internet.

- Provide fall-back audio-conferencing capacity for teachers to use when video-conferencing connectivity to any single site or across the network is compromised.

- To ensure that high quality audio connectivity is available to all video-conferencing participants, focus on the quality of the audio in video-conferencing classrooms. This will likely include use of wireless microphones by teachers and multiple, distributed microphones for students.

- Develop and maintain the capacity to remotely diagnose and maintain video-conferencing equipment, including the capability to completely reboot hardware.

- Seek opportunities for professional development and training such as those offered by NAIT related to SuperNet and video-conferencing operation and support.

Recommendations to Alberta Education:

- Continue support for the emerging video-conferencing focused community of practice by:

    - Continuing the secondment of educator/leaders from the system to provide province wide coordination, training and support for the video-conferencing community;
    - Continuing support and animation of the online community begun on VCAlberta.ca; and,
    - Continuing support for the development of PD resources available anytime/ anywhere for new and experienced video-conferencing teachers. These should include:
        - Promising practice guidelines
        - Instructional videos related to both pedagogical and technological training on effective video-conferencing application
        - Community building, support and advice forums
        - Listings of Alberta and global video-conferencing activities and opportunities
        - Technical reviews and announcements of new technologies
        - Results and reviews relevant video-conferencing related research studies.

- Continue to support participative research in which professional researchers, teachers, students, and administrators evaluate and innovate collaboratively, thereby developing the most cost and learning effective educational applications of video-conferencing technologies.

- Support the development of media curricula (i.e., CTS units) such that students are trained in the design and production skills associated with producing video-conferencing enhanced programming.

- Provide support for pilot projects using video-conferencing and other networked technologies, and assess their effect on learning, teaching, and institutional practice and culture.

Recommendations to Students:

- Learn to use the video-conferencing technologies and offer your knowledge to your classes and learning community

- Imaginatively plan for ways that this environment can be most effectively used to enhance your education.

- Be assertive in remote video-conferencing classrooms to ensure that no one disrupts or deprives you of your learning opportunities.

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Appendices

Appendix 1: Definitions

Video-conferencing: The facilitation of a conference among people from remote locations by means of transmitted audio and video signals over a network. In the Alberta Education system, this transmission will take place over the *SuperNet* using the H.323 IP-based video-conferencing protocol. This is not to be confused with the H.320 protocol, which is a telephone line-based videoconference also known as Integrated System Digital Network (ISDN) Video-conferencing.

Webconferencing: A browser-based client/server application that provides video, voice and data transmission to participants at remote sites over a network. This type of application usually involves an "http" request from a personal computer to a web server. Typically, webconferencing applications can facilitate low speed network connectivity equivalent to dial up (56 kbps). Common features include text chat, whiteboarding, application sharing, file transfer, participant polling and provision for lower frame-rate video.

Teleconferencing: An audio conference or conference call, which requires a bridge or tele-convener (audio convener) to bring different telephone parties together (using the Public Switched Telephone Network (PSTN)).

Webcasting: Near real-time distribution of live video over a network to viewers at remote sites using a software-based video player or web browser plug-in (e.g., *QuickTime*, *Windows Media Player*, or *Real*).

Videostreaming: The retrieval and viewing of a pre-recorded or archived content. The lesson or presentation is viewed via a web browser using a movie player plug-in (e.g., *QuickTime*, *Windows Media Player*, or *Real*).

Audiographics: The simultaneous transmission of voice and data across local telephone lines in a way that is interactive between instructor and participants at remote sites. There is no video transmission in this type of application.

Appendix 2: Literature Review

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

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 divisions, 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 is 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 who 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 the1950s (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 that 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-Blatchford & 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 are 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 videoconference 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 that 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 were equipped with sophisticated videoconferencing suites that included document cameras, electronic whiteboards, multiple monitors, cameras, microphones, and 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 videoconference 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 others' 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 benefit of connecting students to scientists, experts, and professionals, ("bringing the community into the classroom") the authors suggest, is to enhance 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 was 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 articles 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 a 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 drawing diagram 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 have 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 been 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 which 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 which 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), 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 communities' 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 impersonalness).

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, videoconference 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 the 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 that 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 import 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.

Appendix 3: Video Clips

The video clips are available online at http://www.vcalberta.ca/community/videos.cfm (under VC Research Videos).