Canadian Research on Information and Communications Technologies: A State of the Field

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ABSTRACT

On-line learning is a “pan-Canadian priority” and many initiatives have been undertaken to support technology integration in the k-12 and postsecondary education sectors. This paper reviews Canadian research on information and communications technologies in education since 1996. Research has focused on knowledge building and collaboration, their application in k-12 and postsecondary classrooms/ courses, and professional development involving preservice and practicing k-12 and postsecondary teachers.

The paper highlights the move from a focus on the technology to its pedagogical possibilities, the continuing need for an adequate infrastructure and sufficient equipment, and the importance of time and purpose as factors influencing the speed of technology integration in education.

Policy concerns were identified in the following areas: infrastructure, administration and organization, learning and teaching, and content development and a series of research directions involving more classroom-based as well as longitudinal research was called for. An extensive bibliography is attached.

There has been an explosion of Canadian writing on information and communications technologies for the K-12 and postsecondary education environments. Some of it is normative, some practice based--providing advice based on the conclusions of early adopters and increasingly, some is evidence-based research. In this paper I attempt to sketch out the major areas of research, identify directions and topics, raise relevant policy issues and identify additional research opportunities.

Orientation

How do we talk about information and communications technologies (ICTs)? The most common language we use in talking about ICTs and education is to focus on the *impact* of these technologies. As Alain Breuleux (2001) has pointed out, to do so is to speak as if one entity, education, was being attacked by another--technology, like a meteor coming to earth. Technology, he points out, is not an "ingredient" to be added to education, but instead is an "enabler", part of a larger change process that is renewing and transforming education. Other writers (for example, Fullan, 1999; Laferrière, 1997; Lewis, Smith & Massey, 1999) have also pointed out that we cannot discuss the use of ICTs in education without considering the changing context of education. ICTs are one aspect of change; our focus is their use to enhance learning.

Organization

I will begin by briefly framing the paper within the Canadian context for the use of ICTs. Then I will turn to the research in the K-12 sector and discuss research on ICTs in classrooms, in on-line learning, and in teacher professional development. In the postsecondary education section, I will focus on classroom applications, teacher education and faculty professional development. I will then try to synthesize these findings under the policy questions posed in the earlier PCERA paper (Haughey, 1999) and conclude with possible areas for further research.

Internet Use In Canada

Internet use in Canada continues to rise. In 1994, 18% of Canadians were using the Internet. In 1999, the percentage had risen to approximately 42%. Internet use from school also rose reaching 14.9% (Dickinson & Ellison, 2000). In a recent Statistics Canada survey on individual Internet use, "during the year 2000, an estimated 13 million, or 53% of Canadians over 15 years of age said they used the Internet at home, work or somewhere else in the previous 12 months" (Dryburgh, 2001, p.1). Of 15-19 year olds, 90% reported using the Internet. "Over half of the households with children in the home between ages 5 and 18 have purchased a computer specifically for their children and in 83% of those households with a computer and Internet connection, children used the Internet at home" (p. 7).

Although every willing school and library has been connected to the Internet, there is still concern that access is not even across Canada. Reddick, Boucher & Grosaillers (2000) considered there to be a dual digital divide, first on access, and then on cost, literacy and choice. There are many ways of interpreting the divide besides access although that is important. For example, the position of Aboriginal peoples was raised in a number of studies (Voyager, 2001; Facey, 2001; Greenall & Loizides, 2001). The accommodations that have to be made when there is only one line into a community or when the modem speed is very slow were outlined by

Siedlecki (1996) in her description of course development for the University of Northern British Columbia. Similarly, Wakeham, Silva and Bracewell (1998) examined the offering of a combined classroom and on-line course in Baker Lake and Pond Inlet where there were severe restraints on technology (i.e., one computer per school) and a fragile infrastructure which limited communications to e-mail messages. Despite the difficulties, Inuit teachers in the course made web pages in English and Inuktitut. They saw benefits from their acculturation to the technology and were now able to use the technology with their classes. McAuley (2001) described issues faced in the development of computer-based learning in the Eastern Arctic. Greenall & Loizides (2001) identified "the issues and challenges faced by Aboriginal communities when using learning technologies for education and skills development and the solutions they were initiating in order to develop digital opportunities" (p.1). All these studies note the importance of culturally sensitive approaches to course development and provision.

Overall, based on the work of a number of researchers (eMarketer, 2001; Ertl, 2001; Ipsos-Reid, 200; Rotermann, 2001) it would seem that while every school is connected to the Internet, the numbers of computers in schools varies sufficiently to limit use of the Internet to searching for information. Ertl (2001) found that "mathematics was the most likely subject to be taught using instructional software at all three levels of education" (p. 61) followed by geography, language and informatics. Importantly, Ertl reported that students in both age groups more often sign on from home than from school.

ICT K-12 Applications

This section explores the use of ICTs in K-12 classrooms, ICTs in on-line learning, and K-12 teacher professional development for technology integration.

On-line Work in K-12 Classrooms

Research in this area has two major foci: the application of cognitive theories in developing computer-supported learning environments, and explorations of collaboration in schools.

The work led by Scardamalia and Bereiter (1999) focuses on distributed cognition and communal knowledge-building through active learning and problem-solving. Using a specially designed on-line database that can handle multimedia text and graphics, and in cooperation with many other scholars in different countries, they have explored the use of this environment in schools. This work was funded by the National Centres of Excellence program and has an extensive publication record (http://csile.oise.uitoronto.ca/).

CSILE or Computer Supported Intentional Learning Environments was designed to provide support for collaborative learning and inquiry. It is based on the belief that a group, whether grade 3 science students or their university counterparts, can identify a question and, through putting what they know into a database, will generate new questions and challenge previous assumptions. The group provides multiple perspectives on the issue and works collaboratively to build up the knowledge of the group. It supports greater student autonomy and involvement in curricular decision. This involvement encourages more authentic peer conversations and emphasizes understanding related to real world problems rather than memorization. Within the classroom, CSILE is an asynchronous database that retains what students have submitted and

allows for continuous rethinking through providing opportunities for reflection. It is an attempt to make visible knowledge-building in a collaborative environment. In 1997, Knowledge Forum, a commercial product based on CSILE was launched.

Silva and Breuleux (1994) proposed the use of participatory research in exploring the introduction of Internet-based collaborative learning activities in schools and most researchers have adopted the collecting of both experiential and summative outcome data. Lamon, Reeve and Caswell (1999) reported the results of an action research study that sought to move student teacher participants to an enriched level of problem-solving and theory-construction. Using links with a classroom CSILE environment, they helped the prospective teachers link theories of instruction and cognitive development, with their own assumptions and knowledge about the topic, and the actual thought practices of students.

Observing practice is often essential to understanding student learners' use of technologies. Willson and Wolodko (2000) observed two students in grade one and grade three act as peer tutors to their classmates. The software promoted mathematical problem solving dialogues among the students. Peer tutoring turned out to be worthwhile and beneficial. The student tutors demonstrated very different tutoring styles but both were effective. The students and their tutor sustained a high level of interest and discussion during the tutoring session which lasted for about an hour. Inkpen and her colleagues (1999) examined comparisons of elementary students playing collaborative puzzle games on the computer and with paper. They found the children more engaged and more active when playing on the computer. Providing every child with an opportunity to use the computer at the same time reduced time off-task behavior and increased the sense of collaboration. Tiessen and Ward (1997) also used various technologies to explore collaboration. They combined a video project, a CSILE database and strategies from the Fostering Communities of Learners project, all of which required collaborative activities. They found that each aspect not only engaged students in collaboration in a slightly different way but also built on each other to provide for sustaining, productive, knowledge-building collaboration.

While these studies focused on classroom activities, Basque and her colleagues (1998) used action research to develop a model for a computer enriched high school. Guidotti (1994) had identified a number of factors that contributed to the low level of ICT implementation in Québec schools. These were a lack of a strategic or long-range vision for the integration of ICTs; technology plans that were not integrated into the school's overall plans and decisions made without consultation among the staff; a lack of training, information and support in the use of ICTs; and an inappropriate and inadequate technological and organizational infrastructure. Bibeau (1996) added that new initiatives tended to focus on the software rather than on change processes. He and other researchers from the LICEF Research Centre brought together administrators, researchers and teachers from two schools. They first developed a model of all the communications used and the technology resources available at the two schools. They used a systemic model of change to develop a strategic plan for a technology-integrated school and then worked with staff and students of the two schools to implement it. The ICT implementation procedure provided a model for other schools (Basque, Rocheleau, Paquette & Paquin, 1998). Backhouse (1997) also described the process and experience of designing a rural school that focused on integrated applications of technology. The study serves as one model for creating staff appreciation of technology in an environment where there were no additional funds for technology.

There are many examples of K-12 applications of ICTs on the SchoolNet site, but few of these have been written up as research studies. One example of several of these projects was written up by McMahen and Dawson (1995) who explored the use of computer conferencing to enhance the study of environmental education among a number of schools.

ICTs and On-line Learning

While the majority of the literature focuses on technology integration within established classroom programs, in this section I want to include literature focused on on-line learning because schools are developing on-line courses as an alternative for students who, for example, have timetabling conflicts, need to take a prerequisite course, or have sports or music schedules that make regular school attendance difficult. In earlier papers (Haughey, 1999, Haughey & Muirhead, 1999), I outlined the situation in Canada in relation to on-line programs in the K-12 sector. Compared to programs offered through print, audio and video technologies, the numbers of on-line courses offered in K-12 programs are decidedly few but they are growing. The two major foci of the literature have been on organizational changes to increase efficiency and quality, and curriculum design and development.

Obe organizational example is the COOL School consortium (www.coolschool.bc.ca). It was begun by four BC school districts who wanted to offer on-line courses to their students. Sixteen school districts now form the consortium (Lee & Lea, 2001). The consortium has identified four criteria (accessibility, variety, interaction and feedback) which it uses to monitor course development and provision. The courses, which are on a common platform, can to be used by teachers in regular classes as well as by teacher-supervised and home-based distance education students.

Schools have turned to the use of on-line courses for various reasons. Litke (1998) investigated a short-lived virtual program that was included in a junior secondary school. The program was much more labor intensive and technology demanding than had been originally envisaged and teachers had to cope with the demands of developing and offering on-line courses as well as teaching their classroom courses. While teachers saw the program as better than home schooling but not as good as being in class, students and parents were much more positive about the experience. The issues of school capacity, time-tabling constraints and the need to ensure that students are technology competent were used in one senior high school to determine the viability of providing a distributed learning program (a combination of on-line and classroom instruction). Smith (2000) found that there was potential to offer such a program to expand the boundaries of learning beyond the traditional limits of the secondary school classroom.

Concerns about curriculum development were identified by a number of writers. In 1996, British Columbia, Alberta, Newfoundland and New Brunswick each developed modules for a course on information technologies. Stanley (1999) discussed on-line course development in Alberta and pointed out the need for large-scale development efficiencies in a scare-funding situation. Muirhead (1999) proposed an on-line consortium and identified content development as one of the potential benefits. He (2000) interviewed 13 teachers in four on-line schools about how they designed on-line courses and related materials. Alberta has initiated a process of collaborative distributed content development of on-line courses as one of the functions of the Alberta On-line Consortium (www.albertaon-line.ab.ca). Simpson (2001) described the lessons learned through two iterations of the model. In the current iteration (2001-2002), requirements for project

coordination, standard software for authoring and collaboration, course development and lesson development models, workshops on software use and multimedia development, clarified expectations, a support web site and a review process were all outcomes of previous development initiatives.

One example of the possibilities of on-line course materials was described by Lake and Stewart (2001). They discussed cultural and implementation issues in the development and offering of on-line courses using a mandatory NWT course, *Northern Studies On-line*, as an example. This course which is designed to be cognizant of the traditional education models, languages and cultures, is available to students in communities throughout NWT and can be used within a traditional education model as well as a school-based situation. The on-line course provides valuable resources to new and experienced teachers because of the rich resources on the history, culture and languages of NWT it is able to provide.

In 1998-2000, Barker and Wendel (2001) studied comparative satisfaction and achievement rates for conventional and virtual schools in three provinces (BC, AB, ON). However, given the recency of the development of the virtual schools, while satisfaction levels were very high, it was not possible to gather sufficient comparative achievement data.

ICTs and K-12 Professional Development

There has been considerable interest in professional development for teachers in K-12 environments. Gibson and Oberg (1999) spent two years studying issues related to Internet use in Alberta schools. They found from their case studies that many teachers "are in the early implementation stage of Internet use" (Gibson, Oberg and Pelz, 1999, p. 7), only a few teachers in each of the six sites were Internet users, and although the teachers were interested they had limited time. They valued "collegial sharing" rather than having access to inservices for enhancing their understanding. These data were validated by their provincial survey findings. "Rural and urban teachers reported similar levels of Internet accessibility, of technical support, . . . and support for learning" (p. 8). Many teachers had begun to learn about the Internet on their own, and about two-thirds had attended school or district inservices but didn't find them helpful in addressing their needs. The most frequently reported barriers to use of the Internet were limited time available for using the Internet, the pressure to cover the curriculum, lack of school funds to purchase upgrades, and limited access to Internet-connected computers. Case teachers also identified time, "time for learning the intricacies of the technology, time for accessing information and appropriate sites, and time to prepare lessons using the technology" (p. 4).

Two other Alberta studies have sought to identify issues facing teachers that limit technology integration in their classrooms. Szabo and Schwartz (1997) reported the findings of a survey of 1000 teachers who outlined infrastructure and training needs from greater access to computers to local training. The researchers highlighted the need for a provincial vision for computer use in schools and a long-term implication plan. Jacobsen (2001) reported results of a survey of 44 teachers who were members of the Alberta Teachers Association Computer Council. The top issues that influenced their attempts to integrate technology and curriculum were "time for planning and development of lessons" and "insufficient hardware in their teaching area" (p. 4). Technical support and professional inservice time/funding were also important concerns.

Jacobsen (2001) proposed that initial professional development approaches that focused on learning how to operate the computer and use appropriate software applications have helped teachers learn basic skills but have not brought about large-scale reform. The second wave, which has been no more successful, recognized that there was a need to focus more on curriculum and so attempted to link technology and pedagogy. However, teachers were being asked to refocus their pedagogical approaches and roles and at the same time to design and offer lessons which involved technology use with only occasional workshops to guide them and no time to prepare themselves for the task. The third wave is of "situated professional development, consisting of onsite mentorship and support that responds to teachers' individual needs" (p. 5).

The issues in professional development are not only time and technical skills. Egnatoff (1996) who has worked with teachers on SchoolNet, notes that teachers are excited about the prospect of technology integration but they don't have the time to cope with an inadequate infrastructure or insufficient machines. We are still some distance from the recommendation of Fournier and McKinnon (1994) of a new computer for every four children every three years. Also, teachers recognize that the computer and Internet are more than a tool; they need their own answers to questions concerning the value of the Internet and the orientation they will take. They therefore need to grapple with technical, instrumental, pedagogical and valuational issues.

These issues have also been identified by Laferrière and her associates (Breuleux, Laferrière, & Bracewell, 1998; Laferrière, Breuleux, & Bracewell, 2000; Doubler, Laferrière, Lamon, Rose, and others, 1999) who stated the problem as both "knowing about and knowing with" technology (1999, p.1). They believe it is important to recognize that the definition of school is being replaced by learning communities, and that these communities, even when they originate in schools, access and engage others from elsewhere. They content that if professional development starts from the pedagogical perspective of a learning community, then employing "individual, school and networked-based professional development" is likely to address the needs of the majority of teachers. But they also warn that for knowledge building to go beyond what occurs in face to face situations, use of the technology is essential. They provide descriptions of a variety of design experiments that included use of computer conferencing, web-based platforms such as WebCT or FirstClass, and knowledge-building databases like KnowledgeForum.

A number of researchers have described using an individual or small group approach to helping teachers with technology integration. Gibson and Oberg (1999) conducted a number of case studies that involved students working with teacher partners in schools. In each case while the partners worked successfully together, the time taken for the teacher to become familiar with the Internet, to search for resources, and to decide on what students needed to be taught about the process before they could engage them in learning about the topic was extensive. Jacobsen (2001) examined year-long, individualized professional development activities in three elementary schools. The activities were offered by the Galileo Educational Network, (http://www.galileo.org), a non-profit organization supported by government, industry and community partners. The Galileo staff agree to work on-site for approximately 80 days/ year. They meet with the school staff to explore vision and goals and then work directly with individual teachers, teacher teams and groups who are interested in technology integration. The approach is guided by principles of engaged learning and high technology performance and so quality teaching and learning are to the fore. Teachers described students engaged in authentic questions close to their real world experience, and involved in collaborative knowledge-building.

deCastell, Bryson and Jenson (2002) undertook a series of technology integration projects with five teachers and their students over a full school year. They concluded that such school-based projects "where time is given and taken for users to play, to explore, to learn for themselves what is possible" (p. 9) were essential not only for teachers and students but also because they helped educators learn what concerned teachers most about use of the new technologies.

In response to provincial curriculum reform stressing constructivist and inquiry learning, Gross (2000) described the developing and piloting of an interactive website (http://www.qesn.meq.gouv.qc.ca) to provide schools with support through team-building and school-based decision-making strategies. The web site combines a model for future professional development, a way of linking remote English language schools in Québec, and a means to use the possibilities of technology as a topic for discussion as well as a strategy for learning. Gross based her design on the belief that teachers would not be comfortable with the technology until they had used it for their own learning and realised its possibilities. Using this networked learning model school teams can continue the discussion among themselves and also seek advice and assistance from on-line others. Gross and her colleagues were also convinced that "the model of a university team member(s) working both face to face with teachers in a school, on a regular basis as well as available on-line is the most effective way to affect and maintain change" (p. 4). They envisaged this design as an alternative for remote and isolated schools where such collaboration could be on-line and all could be members of a wider community of practice.

In addition, the development of on-line professional development strategies such as SumTalk for Teachers (www.galileo.org/research.html) which has grown out of the Western Canadian Protocol Curriculum in mathematics will further encourage use of new technologies within the mathematics curriculum in schools. One of the longest running on-line professional development networks has been the Education Network of Ontario (www.enoreo.on.ca) and Egnatoff (1996) mentions other province-wide initiatives. Although asynchronous conferencing was initially viewed as an excellent way to involve busy professionals in professional development, a number of researchers (Burge, Laroque & Boak, 2000; Caron, 2000; Kanuka and Anderson, 1998) have identified pitfalls and strategies which need to be kept in mind in designing successful on-line informal education.

Postsecondary Education

This section first outlines research on the administrative and organizational issues for postsecondary institutions, and then documents ICT use in courses, and faculty professional development.

The ICT Postsecondary Context

The context for technology integration in postsecondary institutions has been described in a number of publications (Advisory Committee on On-line Learning, 2001; Bates, 1997; Bartolic-Ziomislic & Bates, 1999; Cuneo & Campbell, 2000, Cuneo & Campus Computing International, 2000; Harasim, 1999; Laferrière, 1997; Lewis, Smith & Massey, 1999;1999a; Lewis, Smith, Massey, McGreal, & Innes, 1998). In general, they point to the ways higher education is changing. Lewis, Smith and Massey (1999a) in a review of policy issues for the use of telelearning technologies in Canadian universities and colleges concluded that each institution

was unique and not all were best served by a large transition to telelearning methods. In contrast, Cuneo and associates (2000) warned that those institutions that have not begun to plan for technology integration will fall further behind. They described a digital divide between those that offer on-line courses and those that do not in terms of infrastructure development, staff training, access to electronic library resources and student computer access and acquisition.

Subsequently, Bates (2000) focused on the questions of the economics of on-line learning. Based on a series of case studies of university and college programs, Bartolic-Zlomislic & Bates (1999) identified the potential benefits of investing in on-line learning as being access to new markets, international partnerships, economic and educational benefits. The limitations involved the need for start-up funding, the additional time required, and appropriate administrative and student support systems. Daniel (1999) has also stressed the need for the application of economic utility models in making technology decisions.

ICTs and Teacher Education

One area where technology integration is both curriculum content as well as a pedagogical tool is in Faculties of Education. A number of provinces have mandated implementation of new technologies programs. These have required reorganization of university teacher preparation programs (Gibson & Nocente, 1998; Jacobsen & Clark, 1999).

One project under the TeleLearning_National Centres of Excellence (TL_NCE) initiative was on Technology for Advanced Collaboration among Teachers. Led by Thérèse Laferrière, this project sought to develop a Telelearning professional development school, meaning a virtual community for preservice teachers. In a paper prepared for the 2001 PCERA Symposium, Laferrière and her associates pointed out that with the access to the Internet the teachers' primary workplace, the classroom, is changing, and teachers' and students' roles are shifting. The changes in the classroom can be partly attributed to a pedagogical interest in constructivist approaches to learning which encourage student engagement in authentic projects, student group work, greater student participation in instructional decisions, a focus on learning outcomes, and collaborative knowledge building. The researchers believe that teacher preparation and professional development practices that focus on constructivist assumptions and use ICTs are the most likely means for making networked classrooms an emerging reality although issues of scaling up remain challenging.

Within the TL-NCE Educating the Educators theme, four projects focused on teacher education. The CITE project at the University of British Columbia (http://www.educ.ubc.ca/courses/cite) linked participating staffs in 4-6 elementary schools, pre-service and mentor teachers and university researchers and faculty through a web-site. The student teachers worked first to develop technical skills and then, in cooperation with the elementary teachers, designed and produced technology-mediated learning activities using Web-based and hypertextual media, which they used in the schools during their practica. The project has been successful but the challenge will be to scale up the levels of support and instruction required by pre-service teachers to support teachers in participating schools.

Student teachers in the Knowledge Building project at the Ontario Institute for Education, University of Toronto (OISE/UT), used Knowledge Forum to develop their own learning in two ways. First, their conceptions of teaching were revised as they saw the interactions among students and mentor teachers in the participating schools and discussed these with the researchers and instructors. Secondly, they found their own conception of the subject matter challenged by the children's conceptions of the topic (http://kf.oise.utoronto.ca/VirtualTours/) This encouraged them to discuss with the participating mentor teachers and their instructors alternative knowledge building approaches which they could use with learners. The model is one that has been replicated with students in different content areas.

The project at Laval University, TACT, (http://www.tact.fse.ulaval.ca) involved teachers (mentor teachers and student interns) at a school some distance from the campus who have Internet access to instructors on campus. They use a variety of software platforms to support collaborative activities, from research and journal writing, to reflective practice on their teaching, to case-study writing and discussion. Linked through the main TACT web site, they may discuss with other researchers or students from other classes. During student practica, they have frequent access to other members of the Web for support and advice and can post examples of their technology-mediated projects for comment and discussion.

The McGill initiative, TL.PDS Net (http://www.education.mcgill.ca/olit/institute), involves teachers from ten participating schools in work on technology integration in collaborative on-line environments. Each year, practicing and student teachers attend a Summer Institute where the novice and the experienced teachers work together to design technology-based activities for the teacher's classroom. During the fall term, the group continues developing understanding through information sharing and knowledge-building activities. The student teachers then go to these schools on practica. They participate in a community of practice as they and their cooperating teachers continue to develop and test technology-mediated projects in the classroom. Multiple projects have been developed. These range from schools setting up their own on-line discussion groups to a group of teachers collecting and assembling cases on their experiences as "lead" teachers for communal knowledge building, reflection and multiple interpretations. Another group is exploring the use of recording devices such as video clips to help teachers explain issues of their practice and develop cases of situations from which others can learn.

Another example of projects focused on building capacity of pre-service and practicing teachers is one that has been undertaken in Alberta. Under the leadership of the Galileo Network (www.galileo.org) teachers in three schools in one jurisdiction will work on technology integration in cooperation with students from the Universities of Calgary and Lethbridge. Practicing teachers will have the opportunity to enrol in diploma, certificate and degree programs designed to meet their needs. Independent funding for technology will be sought from industry partners. All of these models ultimately focus on a small group where trust, respect and support are valued and whose members are prepared to learn together and from each other. These are small projects within large teacher education programs. The challenge to scale up is immense and puts further pressure on the issue of faculty professional development.

ICT Use in Postsecondary Classrooms

Quite a few studies describe the experience and assess the influence of using on-line technologies in post-secondary classrooms. Many use technologies as an extension of classroom practices, often to post course outlines, lecture notes, additional resources, useful links, possible examination questions and FAQs. Some have adopted technology as an integral aspect of classroom demonstrations using its multimedia capacity to enrich examples from the text. Some use it for discussion and presentation, using databases and spreadsheet to keep track of the class members' thinking. Some use asynchronous conferencing to extend class discussions and in large classes to involve previously silent students. Some have their entire course on-line often using a software platform that includes web pages, conferencing and a variety of tools and freeing the students to sign on where and when they choose.

Much of the research has focused on the analysis of teaching and learning on-line. Harasim and her colleagues (Campos & Harasim, 1999; Campos, Laferrière, & Harasim, 2001; Harasim, 1999) have presented the results of analyses of the many postsecondary courses using Virtual U software offered at different institutions. In 1999, of the 230 courses offered, 72% were in mixed-mode, often by senior professors, and in a wide variety of disciplines. Students (83% of those surveyed) were positive and supportive of the mixed mode as were the instructors. Learning designs involved discourse-based, collaborative learning. Harasim (1999) commented, "In face-to-face classes, instructors use approximately 80%+ of air time: on-line, students send about 85% of the messages" (See also Blanchette, 2001).

Campos, Laferrière, and Harasim (2001) focused on the mixed mode courses. The courses used asynchronous conferencing and the most common roles of the instructors were to facilitate the discussions and to present content. In terms of instructional designs, they identified seven variants from group projects to cases, lectures with links, seminars, and support for teaching practice experiences. They chose to examine those with group projects and categorized the level of collaboration They ranged from vague (being in a group but not working on a group-assigned task), to modest (groups working together cooperatively but not on a group assignment) to strong (students in group, working together cooperatively on group assigned task). They proposed that effective on-line learning should involve collaborative activities through networked pedagogy.

The changing role of the instructor, the importance of collaboration, problem-solving and active learning, and the structuring of the discussions, which are reflective of various approaches to the teacher-learner relationship, have been taken up by other researchers. Initially researchers (e.g., Teles, 1998) focused on interaction patterns as indications of involvement, and others (Campos, 2000; Dejardins, Ricciardi-Rigault, Plante, Dumas & Henri, 1996; Fahy, 2002, 2000; Rourke, Anderson, Garrison & Archer, 2001) sought to develop analytical tools to help identify how argumentation and knowledge-building occurred.

Garrison and his colleagues (1999) have proposed a model of teaching and learning on-line based on a community of inquiry model. The model assumes that in this community, learning occurs through the interaction of three core components: social presence, teaching presence, and cognitive presence. Social presence (Rourke, Anderson, Garrison, & Archer, 1999) refers to the learners' ability to participate socially and emotionally in the community. It is viewed as helping to sustain interest and involvement in critical thinking. Cognitive presence, they (Garrison, Anderson & Archer, 2001) suggest, refers to the ability to construct meaning through sustained

communication in on-line environments. Teaching presence (Anderson, Rourke, Garrison, & Archer, 2001) refers to the activities of the teacher designed to actively engage the learner and sustain the communication. Teacher presence was also an issue for Teles (2000). Bullen (1998) concluded from his study of participation in an on-line course, that the emergence of a dynamic and interactive conferencing environment that facilitates critical thinking requires a concern for appropriate course design, relevant content, instructor facilitation strategies and student characteristics.

Acadia University chose to include laptop computers for all incoming students as part of their fees in 1996 and there are a number of research studies associated with that implementation. They deal with the use of a variety of multimedia interactive technologies in a wide range of courses from introductory psychology (Symons, 1997), to physics (Retson, Williams & Symons, 1999), writing (Boyle & Rigg, 1999), feminist pedagogy (Chegwidden, 1999) and exercise physiology (Pelletier, Ness & Murphy, 1999). These studies have tended to find that Acadia Advantage students, those with laptops, achieved higher grades than their non-Advantage counterparts. Boyle and Rigg found themselves having to change their pedagogy to include technological approaches and were challenged by the difficulties in measuring achievement gained through group work against that from individual writing. Pelletier and her colleagues introduced problem-based learning through technology and found that students commented positively and the project verified the viability of the teaching methods and student acceptance.

Other studies have looked at use of computer mediated communication often in a flexible learning combination of computer mediated conferencing and site-based classes. They include courses in social work mental health (Knowles, 2001), health and human services programs (White, 2000), business administration (Parker & Gemino, 2001), and organizational theory (Vibert, 2001). The outcomes of these experiences include changes in curricula, revitalization of the instructor, changed pedagogy, strong student support and greater student responsibility. Hick (1999) who examined an on-line "Introduction to Social Work" course, found that students enjoyed and wanted Internet-mediated learning in all their courses whether entirely Web-based or mixed-mode and believed it improved their learning. Knowles (2001) reported similar findings for his course that combined Web-based modules with classroom instruction. White (2000) studied the design and offering of print and Web-based versions of three health and human services courses. She recommended providing faculty development, developing quality courses, minimizing students' barriers to access, and providing on-line support tools as the most beneficial future activities. Parker and Gemino (2001) sought to assess differences between conceptual and technical aspects of students' learning in a comparison of Web-based and classroom versions of a course. They found that students in the Web-based course were better conceptually but weaker in the technical aspects where they had less access to protocols and analogs and concluded that all students could benefit from a flexible learning version.

Some studies focused more specifically on students. Burge (1994) asked learners for their reactions to computer conferencing and highlighted the importance of instructional management strategies as one aspect of the pedagogical role. This included modelling summary writing, setting up protocols for involvement and posting, and strategies for chairing discussions. Karsenti (1999) found that although students' motivation dipped after they were four weeks into the semester it was high again at the end of the course. Fullan (1999) refers to this as the implementation dip, the motivational downturn as the combined changes call for new patterns of

response and personal change. This suggests the importance of feedback and support at this point in an on-line course. De Simone, Lou and Schmid (2001) used metaphor as a strategy to minimize student feelings of isolation and to provide for a more integrated understanding of the on-line course material. The student outcomes and discussion during the Web-based course showed that these goals were achieved.

Ross (2000) explored the impact of students' individual differences such as learning styles, background computer skills, and prior knowledge on their participation in on-campus and Web-based versions of a course on "Law and Disability in a Community Rehabilitation" program. He found that the Web-based students achieved significantly higher grades than the on-campus group while the on-campus group spent more time on overall course learning. While all learning styles were accommodated in the Web-based environment, Concrete Random (CR) learners did less well in the classroom setting. There was greater interaction on-line, and collaboration was the best predictor of success for the on-line group. Collis and her colleagues (Collis, Winnips, & Moonen, 2000) studied on-line students' final scores based on two forms of participation, that is compulsory and optional structured tasks with instructor support. They found from their preliminary study that although students in the structured route spent about twice as much time on the course, they did not do significant better on their final grades. Kennepol (2001) examined the utility of virtual labs as one aspect of an undergraduate science course and recommended their use under certain conditions. Haggerty, Schneberger & Carr (2001) compared peer-to-peer interactions with face-to-face, video-conferencing, and on-line situations. They found that analytical interactions were perceived to occur more frequently, were longer and of a higher quality, and contributed the most to learning in the asynchronous on-line environment. Janes (1999) described the influence of culture on interaction in her exploration of student reactions to their involvement with their on-line peers in international on-line learning courses.

Some researchers have examined student demographics. Wallace (1996) reviewed the demographics of students who had enrolled in independent study courses at University of Manitoba over an 11 year period. She noted that this population was now younger, urban, and full-time, that geography and age were no longer defining characteristics of distance education students and that working while being enrolled full-time was common. These findings have institutional and program design implications. Of six demographic variables, McLean and Morrison (2000) found that only education and residence in urban or rural areas were significantly related to the rate of participation in a computer conferencing course, findings that support the national participation figures.

Other studies have moved from examination of student achievement, motivation and satisfaction to an exploration of aspects of the instructor's role (Haughey & Anderson, 1999). There has been extensive discussion of the absence of an institutional model for development involving instructional designers and visual designers as well as content experts in many of the courses offered. Wiesenberg and Hutton (1996) concluded from their involvement in teaching two on-line courses that the technical challenges and the increased time required to process written messages and to develop in-depth dialogue were striking and that there needed to be institutional support. From an analysis of the experiences of colleagues, Mitchell, diPetta & Kerr (2001) recommended that 'lone ranger' or 'greenhorn' development models should be replaced by a more institutionally grounded model. Annand and Haughey (1997) linked course design to the pedagogical philosophy of the instructor and noted the differences that arose in design even

when all were using an on-line environment. Bernard and Lundren-Cayrol (2000) sought to examine the influence of teacher-directed versus student choice group formation and high versus low teacher intervention in an on-line environment. While their results weren't entirely consistent, they did note the advantages of teacher-assigned groups and low teacher intervention in-group discussion. A number of studies (Andrusyszyn, van Soern, Laschinger, Goldenberg & DiCenso, 1999; Cragg, Andrusyzyn, & Humbert, 1999; Gillis, Jackson, Braid, MacDonald and MacQuarrie, 2000; Office of Partnership for Advanced Skills, 1998) have explored the choice of technology and identified a series of principles to guide technology selection. Ellis (1997) made the case for the use of synchronous conferencing to retain the characteristics of the classroom environment.

ICTs and Postsecondary Professional Development

Much of the work on faculty professional development has focused on the individual faculty member and a number of institutions have undertaken surveys of staff to obtain baseline data about technology use. In the earliest studies, there was substantial discussion about computer anxiety and even phobias about computer use. Wright and Stammer (1996) provided a list of instructors' hesitancies. These ranged from fear of the unfamiliar and fear of technology itself, to fear that their role as content expert might be challenged or fear that the quality of student interaction might be reduced, or even that if they waited long enough the technology would become easier to use. More recent studies (Anderson, Varnhagen & Campbell, 1998; LaRose, David, Dirand, Karsenti, Grenon, Lafrance & Cantin, 1999; Jacobsen, 1998; Proulx & Campbell, 1997) have tended to use Roger's Adoption of Innovations model as a conceptual framework and categorize the minority of faculty who use computing technologies in their teaching as "early adopters". Anderson and his colleagues suggest that the lack of mainstream implementation may be due to a chasm between these two groups in that one is intrigued by the possibilities of the technology while the mainstream group is more concerned with teaching, administrative and research tasks. However, LaRose and associates suggest that it may be linked to the academic discipline. They pointed out that the team-based research approach in fields such as medicine, engineering and the natural sciences is often reflected in more frequent and complex computer use.

A number of researchers have undertaken studies of faculty involvement in technology integration. Jacobsen (1998, 2000) explored the relationship between excellent teaching and early adoption of technology integration among faculty members at one university. She, too, noted differences between early adopters and mainstream faculty in the methods they chose to learn about the technology, the types of support and training they preferred, and the motivators and impediments they reported. Malinski (2000) discussed the implementation of technology-based instructional techniques with 12 faculty at one large university. He found that they were moving towards a more constructivist orientation in their teaching, and had used a variety of tools. They were hesitant about proceeding because of issues such as the increased amount of time required to respond to student e-mails, the potential barrier to learning if all students don't have Internet access, and their concerns about intellectual property rights and responsibilities if they put their course materials on-line. Nnazor (1998) also explored the use of information technology in teaching at a major university. He found the faculty members' attitude to be generally positive but noted that despite that there was relatively little implementation. The hindering factors that emerged from his interviews were: (1) perceived or experienced

pedagogical limitations of technology, (2) lack of time needed to learn or use the technology, (3) lack of professional reward for teaching with technology, (4) lack of appropriate skills, (5) lack of resources and equipment. He also identified three key organizational weaknesses: a lack of coordination of various initiatives, a neglect of faculty members' motivational needs, and the lack of policy-making authority in the units responsible for technology integration. Frank (2000) who explored community college instructors' views of their technology integration provided a more positive picture. All the instructors in her study saw web-based learning as being empowering for students and one that helped move them out of the content provider role. Most had found their involvement had generated a sense of renewal in mid to late career. The necessity of collaboration and its contribution to professional development were especially strong themes.

The increasing use of management information systems for administration and computing technologies in research, whether for computing, databases, visualization or networking, suggests that teaching may be the last area to adopt technology integration. Anderson (1999) has traced the development of programs and staffing at a major university to try and identify strategies that encouraged staff to employ technologies in instruction. He identified a wide range of strategies that were tried and provided his estimation of their level of success, but he concluded that while computer applications, which he termed supportive technologies, enhance and extend possibilities in research and administration, instructional technologies are disruptive to the current pedagogical culture and economics of higher education institutions. This point was also raised by LaRose and his colleagues (1999).

Other universities and colleges have used a combination of face-to-face sessions and on-line professional development modules to increase staff competencies. Higgins, Sprague and Stewart (2000) described an initiative at their university that uses a Web-based program to improve the information technology skills of faculty, staff, students, and alumni. Participants can access self-instructional models at their convenience. Szabo (1996) has suggested that four factors need to be considered in assisting technology integration: (1) the presence of a directional vision from the administration, (2) competence in the technology, (3) an adequate infrastructure and support, and (4) the will to change. He reiterates Fullan's observation that willingness to change is the most important factor.

One alternative to this focus on individual faculty was outlined by Gabriel (1999). At her university, the members of one Faculty made a commitment to explore and implement Web-based learning in course offerings, when pedagogically appropriate. Support from the administration was critical to the success of the project and was visible in the release time grant and their strong encouragement throughout the project. Workshops, team consultations and demonstrations all helped enhance competence. A technology facilitator provided ready support and faculty were in general agreement that they would consider inclusion of web-based components in their courses. Although this approach began from a technology perspective rather than a curricular one, it would seem that it is only when a group decides to renew their pedagogy and uses networked learning environments to sustain it that major shifts will occur.

POLICY CONCERNS

From a policy perspective, I would like to go back to a set of questions I posed in the PCERA 1999 paper (Haughey, 1999) and see what we can now say about them.

Infrastructure

The first question asked about a stable infrastructure. We now have increasing evidence that students are accessing the Internet at school and at home. They use the Net for school-related activities and much of that involves information searching. There are still large rural areas where access is slow if not impossible. While the numbers of households using cable modems has more than doubled, approximately three-quarters of Canadian communities do not have high-speed access (ICT, 2001). The development of a high quality infrastructure is essential to ensure equity of access and that pedagogical strategies are not immobilized by inadequate and expensive Internet connections.

Adequate technological support and software upgrades must also be ensured. New computer applications require more speed and capacity. The issue of sufficiency of computers is more complex. We should continue to decrease the pupil-computer ratio but we also need to consider alternative strategies for technology-enhanced learning. For example, we should monitor carefully the developments in wireless technologies and the classroom use of handheld devices that increasingly may be able to provide some of the services learners require.

Administration

It is not sufficient to expect that individuals will adopt technology in their teaching. Provincial governments, school districts and school administrators are important in ensuring that there is a consistent purpose and adequate support for technology integration. Teachers need to understand how technology integration can enhance collaborative knowledge-building, critical thinking, creativity, and student responsibility. These strategies are best worked through within the school but the focus should be on using ICTs to enhance pedagogical strategies that are learner-centred, inquiry-based and involve collaborative learning.

Learning

What effective learning strategies and modes of learning make most use of the capabilities of the new technologies? In addressing this question, we have a lot of information from the research groups involved in collaborative knowledge-building. We have evidence that such learning strategies work for students on Baffin Island and for those in downtown Toronto. Classroom research in many parts of Canada has demonstrated the utility of a more active, problem-solving, inquiry approach. Using the technology to make visible knowledge-building, assumptions, queries and new propositions, makes it easier for students to consider the contributions of many and to be creative in their response. It is not the technology that is enhancing the learning; rather it the strategies the teacher is using which become possible through the new technologies. Most of these strategies would be impossible without ICTs. We need to continue to document successful strategies that link directly to student achievement.

The fundamental possibility of the new technologies is not as the ubiquitous digital encyclopedia but rather its abilities for asynchronous communications. These help us become learning communities that are not bound by space and time. If we consider schools to be learning communities, then how does that change our conception of school as a place?

At the postsecondary level, the use of asynchronous conferencing has been the focus of research. Data from Canada and elsewhere point to the importance of using discussion to encourage critical thinking, and the text transcript means that no one misses the comment and everyone can rethink the issue and the responses. For example, it is clear that whether it is a credit course or a professional development activity, leadership and facilitation are essential. These are skills we wish to foster in students. We need to identify and promote instructional processes where instructors participate in rather than control learning events and where both cognitive and social concerns are included.

The emphasis in K-12 student outcomes has been reflected in our accountability and achievement frameworks. If we are to promote a more active and involved approach to learning then new standards for activities such as protocols for displaying and marking group work, and collaboration need to be developed.

Teaching

How are experienced and pre-service teachers being prepared to work with new technologies? We have not been able to document large scale strategies that have in themselves been sufficient to bring about technology integration. Most recently, the research focus has been on small projects where the change can be internalized over time. However, this is a slow process and we need alternative strategies while will look more broadly at the issues and attempt to find ways to present alternative pedagogical strategies that can be enhanced through appropriate technology use, possibly through the use of knowledge objects and on-line networks. These require appropriate scaffolding so that teachers can be successful and assured that learners are not suffering in the process. Teachers desire both practicality and scaffolding. We need to find positive incentives that help teachers who want to include technology use and that are reasonable within the busy lives they already live.

In terms of the postsecondary sector, many of the same issues are present. Eventually most faculty will put administrative course materials on their web pages and some may use discussion forms and databases. Those who already work with digitized data have already found ICTs to be an advantage in extending the projects and discussions they can have with students about their own research. More remains to be discovered about ways to focus professional development whether it is at the small group, individual, or department level.

Faculties of Education are already researching different strategies for teacher education (Tardif and associates, 1999) and redesigning programs to fit a more constructivist orientation. Many adopted small scale projects that involve students working with teachers on technology integration over time. These have been successful but if they were to be extended, many more teachers would be required to act as mentors and co-learners. The issue of scaling up remains daunting.

Content Development

This question asked how might the development of multimedia on-line learning resources be realised? We have come some way in attempting to address this issue. Inter-provincial initiatives in shared curriculum development have helped identify essential principles for future ventures. The development of MERLOT, a curriculum object repository for K-12 teachers, is the basis of a database of materials for classroom use. Objects are small segments of content ranging from a multimedia presentation of a concept to a web page of resources. Teachers need to see samples closely linked to curricular objectives before they feel comfortable planning to use them. We need more curriculum examples that exploit the possibilities of the new technologies and are based on collaborative learning designs.

In the K-12 sector we have schools using on-line courses to provide alternatives to students who cannot or choose not to take classroom courses. One advantage of these courses is that the quality is often closely monitored and the media standards are superior to what an individual teacher could easily develop. The course *Northern Studies On-line* is one such example. It provides resources a teacher can use in a classroom or a student can access in a community setting.

The Issue of Large Scale Reform

The use of ICTs in classrooms is not so much an issue of technology as it is an issue of change. What is our vision for education in Canada? The vision statement, quoted earlier, refers to ensuring quality learning environments that reflect local needs and strengths. Some provinces have adopted a more collaborative problem-solving orientation. How does this affect what we seek from schooling that involves new technologies? How will the notion of learning communities affect how we conceive of schools?

Fullan (2000) recently reviewed large scale reform attempts and suggests that we may now be ready to learn from those failures of the `60s because there is a growing sense of urgency about the need for reform. This time we recognize it as a much more complex task with the need to spend much more time on the implementation phase.

Some of the insights and dilemmas he identified pointed to importance of the system context. He suggested that large scale reform will not occur in the absence of a strong teaching profession and corresponding infrastructure which addresses professional development, assessment and accountability and teacher preparation. He stressed selectivity of goals, consistency of processes and coherence. Coherence means an alignment between "individual professional development, learning communities, and program goals and activities." (p. 21). He suggested that it was best to mobilize commitment and capacity through a variety of structures. That way many people will be involved and help sustain the reform. He noted the importance of quality materials. In his 1991 book he identified three changes at the classroom level--changes in materials, in teaching practices and in beliefs. Unlike prior implementations, he suggested, "you can't depend on people's capacity to bring about substantial change in the short run, you need to propel the process with high quality teaching and training materials (print, video, electronic)" (p. 23). The materials need not be prescriptive but they should be based on evidence linking teacher practices to student achievement.

He also proposed systems of pressure and support that involve people in genuine decision-making involving the process. The reform needs to work at the local level but people there have to be able to understand it as part of a bigger picture. Last, reform takes time --8 to 10 years for sustainable reform.

I found these interesting to reflect on in terms of the integration of technology and education. There are lessons we can learn from such reflection. Fullan confirms the importance of professional development and systems of support, but he also stresses the importance of knowing our goals and putting systems in place to monitor the process and support their achievement.

POSSIBLE RESEARCH DIRECTIONS

The relationship between research and policy is seldom direct and in this instance there are sizeable limitations when the implementation of new technologies has occurred only within the last decade and is neither consistent nor comprehensive, and the technologies themselves are evolving rapidly. Issues that would benefit from continued research include:

1. Continued monitoring of infrastructure use; students' in school and out of school use; the impact of wireless telecommunications and handheld technologies. We should also be monitoring the use of assistive technologies to ensure the inclusion of all those who need these adaptations to access ICTs.

2. What effective learning strategies and modes of learning make the most use of the capabilities of the new technologies? It is likely that there is a variety of teaching strategies involving new technologies to enhance teaching. We need more information about these strategies and their implementation in classrooms.

3. We need to assess the impact of high quality, multimedia on-line resources. How do teachers use them? Do they accommodate to different instructional approaches? How have teachers extended the materials in their own classrooms?

4. We need to know more about learning communities. How are they developed? How are they sustained? What pedagogical strategies are best able to encourage critical thinking and collaborative inquiry? Are there cultural and gender issues we should be aware of? What about issues of confidentiality and copyright?

5. Large-scale development may be essential in order to build on the possibilities of new ways of learning. We need to monitor the use of new technologies in large-scale reforms to be able to gain insights from their issues.

6. Professional development was the single most repeated recommendation in any large scale change. What other alternatives besides small scale projects might we employ that could help engender greater technology integration take-up rates? How effective are ICTs in that process? How closely are our practices matching research on collaborative knowledge-building?

7. What have been the achievements of the provincial networks such as Stem~Net or Contact North or Alberta's On-line Consortium? How do they contribute to teacher professional development for technology integration? What strategies have they undertaken? What can we learn from their successes and failures? How can we extend on-line opportunities and encourage teachers and schools to participate?

8. Research on professional development stresses a focus on growth not deficits, on group rather than individuals, and on a systematic focus based on adult learning principles rather than short workshops. What models of professional growth will work best for practicing teachers? What models of teacher preparation can faculties of education use to ensure that all pre-service teachers are proficient in technology integration?

9. Much of our research has documented changes that occurred over a year or two at most because longitudinal studies are expensive. We need more longitudinal data, especially to document changes over time, to identify best practices and to know whether and how implementation has been sustained.

10. We need more participatory research. Our understanding of information communications technologies and their possibilities in enhancing learning will grow through involvement with practitioners. Working collaboratively with teachers on knowledge building around technology integration will help document best practices and benefit others.

Integration of ICTs is not about technology but about change and change begins with the will to learn. How we foster that learning in teachers, learners and ourselves will be our contribution to Canada's knowledge society.

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