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## The Integration of Information and Communication Technology Into Classroom Teaching

*This study provides new images of teachers who are pioneers in the use of information and communication technology (ICT) in the classes they teach. This qualitative study looks at teachers in a high school that is a leader in using information technology in the classroom. The findings indicate that most of the teachers participating in this study were enthusiastic about the possibilities ICT holds for classroom use. Examples are given to illustrate how information technology is being used in this school to enhance classroom teaching in several subject areas. Concerns teachers have about the use of technology were identified as issues that could determine the success or failure of the use of ICT in high schools. These concerns include: maintenance, inequalities, the need for training, information overload, the pace of change and stress, plagiarism, business involvement, and teachers' time.*

*Cette étude présente de nouvelles représentations d'enseignants qui sont des pionniers dans l'emploi des technologies de l'information et des communications (TIC) dans les cours qu'ils donnent. Cette recherche qualitative se penche sur des enseignements dans une école secondaire qui se classent comme chefs de file dans l'emploi des technologies de l'information dans la salle de classe. Les résultats indiquent que la plupart des enseignants qui ont participé à l'étude étaient enthousiastes face aux possibilités des TIC en salle de classe. L'auteur fournit des exemples illustrant différentes façons dont on se sert des technologies de l'information pour améliorer l'enseignement de plusieurs domaines en salle de classe dans cette école. Les préoccupations qu'ont évoquées les enseignants quant à l'emploi des technologies ont été identifiées comme des facteurs pouvant déterminer si l'emploi des TIC allait réussir ou pas dans les écoles secondaires. Parmi ces préoccupations, l'on retrouve: l'entretien, les disparités, la nécessité de la formation, la surcharge d'information, le rythme du changement, le stress, le plagiat, l'implication de la part des entreprises et l'emploi du temps des enseignants.*

### Introduction

The use of information and communication technology (ICT) such as Internet applications, CD-ROMs, video technology, and various computer attachments and software programs has caused many changes in society. These changes have not just been of a technical nature, but more importantly of a structural nature. Many of the major institutions of our society have changed, and how we live our daily lives has been affected. However, the impact on education may just beginning to be felt as teachers integrate this new technology into their teaching. In the early stages of using ICT in teaching, looking at the experiences of teachers at a high school in the forefront provides some clues as to what possibilities and problems may be presented with this new technology.

Classroom resources are dramatically expanded by the use of ICT, which makes many resources, including original source materials from all over the

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world, available to students, teachers, and school administrators. For example, the Internet brings information, data, images, and even computer software into the classroom from places otherwise impossible to reach, and it does this almost instantly. Access to these resources can facilitate individual and group projects, collaboration, sharing ideas, and can make available curriculum material not found in schools without Internet access.

#### *Purpose and Research Questions*

The purpose of the study is to provide a better understanding of how the use of ICT is affecting the work of teachers. Investigating a school at the forefront of using ICT provides images and insights related to this location that might be useful to others undertaking work in this area. The research questions are: (a) How does the use of ICT change the work of teachers? and (b) What problems or concerns do teachers identify in relation to the introduction of ICT?

#### *Literature Review*

In some ways the debate about the use of ICT is still in the early stages, and conflicting views have been established as more information is gathered related to the use of this new technology. Some see ICT bringing about an era of unlimited potential in education, whereas others see the use of technology as misguided and problematic. Bass and Rosenzweig (2001) note that “extravagant predictions of utopia or doom have accompanied most new communications technologies” (p. 42). To make the point, they give examples of what people were saying about the telephone shortly after it was invented. Some had seen it as bringing about a “kinship of humanity,” whereas others had seen it destroying interpersonal relations and weakening society. In this review of the literature I present some of the strong positions that have been taken and also review some of the research that has been done on the use of ICT in educational environments.

Rawlins (1992) relates the changes brought about by the Internet and information technology to what happened as a result of the invention of the printing press. He sees the data highways connecting schools, colleges, universities, researchers, and industry, as helping to start a society-wide revolution similar to what resulted from the invention of the printing press. Noted academic and management guru Drucker (1999) makes some comparisons between the industrial revolution and the changes that are currently happening because of the introduction of ICT. The real changes, he says, will come as a result of changes to our “mental geography” (p. 50) as we begin to realize the full potential of the new technology.

In an environment of increasing technological change an important consideration is the process that individuals and organizations go through to take advantage of new possibilities that are available. The work of several academic writers points to the importance of early adopters in the broader acceptance and integration of innovations. Rogers (1995) provides a comprehensive examination of the development of diffusion or change theory. Drawing on the work of many other researchers in this field, he provides insight into topics such as the generation of innovation, change agents, and the consequences of innovation. He examines the four elements of diffusion that determine how an innovation is adopted—or if it is adopted at all—the innovation itself, the communication channels, time, and the members of the social system.

Moore (1995) examines the technological adoption life cycle from a business perspective and identifies strategies that can be used to guide adoption. He builds a case that truly discontinuous innovations—those that require a dramatic change from past behaviors but that result in dramatic new benefits—require special adoption strategies. He points out that superior products often fail and that many companies fail to make the most of innovative products because of how they are introduced. Both Moore (1995) and Rogers (1995) recognize this critically important role of “innovators” and “early adopters” in the change process. With many innovations, the recommendations of a respected peer can substitute for such trials, thus speeding up the adoption process.

One of the leading models for change in educational settings has been the concerns-based adoption model (CBAM) developed by Eugene Hall and Associates. This model focuses on the individual faced with a new technology and how he or she reacts (Newhouse, 2001). It provides a change process model involving stages of concern and level of use indicators. Individuals in the process of adoption pass through seven stages of concern from *awareness*, where they are not concerned because they are not aware of an innovation, through to *refocusing*, where the adopter looks at how to improve on the original innovation. The levels of use during the change process correspond to these stages of concern. Sherry, Billig, Tavalin, and Gibson (2000) also note that as teachers pass through various stages of adoption, they will require different kinds of support and professional development. They note that at this point, most attention has been on the earlier stages of the adoption process where providing information is enough, but later more collegial sharing is required as teachers move to integrating technology into the curriculum. Dias and Atkinson (2001) as well note the importance of recognizing the stage or phase of adoption the teacher is in when determining what strategy to use for integration or evaluating best practices.

Tapscott (1998) outlines eight shifts that he believes educators and students need to make if they want a more powerful and more effective learning paradigm. These shifts, he suggests, are: from linear to hypermedia learning; from instruction to construction and discovery; from teacher-centered education to learner-centered education; from absorbing material to learning how to navigate and how to learn; from school to lifelong learning; from one-size-fits-all to customized learning; from learning as torture to learning as fun; and from teacher as transmitter to teacher as facilitator. Both Perelman (1992) and Salisbury (1996) see classrooms as obsolete and not suited to meeting the educational needs of students in the future. The change process happening in education, they think, is quite natural, similar to what has happened in other instances like the steam engine, the kerosene lamp, and the horse-drawn carriage.

Many scholarly writers see information and communication technology causing dramatic changes in society. Tapscott (1998) documents the rise of a new generation familiar with new media technology centered around the Internet. He gives examples of how this new generation (the Net generation or N-Gen) is playing, communicating, working, shopping, and learning differently than their parents did. He presents material to support his position that the use of this new technology and the rise of the Net generation is already

bringing about significant changes in society. He thinks this Net generation will automatically expect that information and communication technology will be used for educational purposes. Gilder (1994) is positive about the impact as well, arguing that new paradigms will emerge that will change how we live. Rather than promote mass culture as television did, computer technology will favor individualism and “blow apart all the monopolies, hierarchies, pyramids, and power grids of established industrial society” (p. 61). This view is similar to that expressed by Perelman (1992), Salisbury (1996), and Negroponte (1995), but is different from the views of Robertson (1998), Noble (1998), Stoll (1995), and Postman (1995), who see new technologies being used to reinforce the power structures that exist in society.

Postman (1995) criticizes the use of technology and warns against placing too much faith in the “god of technology” (p. 47). He claims that technology may be useful for teaching facts, but it works against the learning of social values, the main problem facing the schools of today. Stoll (1995) questions the high cost of technology and wonders whether the money would be better spent either on hiring more teachers or on buying more books. He also reflects on the limitations technology could place on teachers who would no longer be required to use their professional skills or be given the rewards that come from helping a student learn. Information and communication technology, according to him, would make teachers’ work less satisfying.

Noble (1998) presents a critical examination of what is happening with the use of ICT in educational environments. He thinks the trend toward the increasing use of technology robs teachers of their knowledge and skills, eventually leading to a loss of control of their working lives. He believes that the conversion of courses to courseware means, “the knowledge and course design skill embodied in that material is taken out of their possession, transferred to the machinery and placed in the hands of the administration” (p. 25). Robertson (1998) also makes the case that the increased use of technology will lead to a loss of control by teachers as our education system becomes more commercialized. She gives examples of how corporations are using ICT to strengthen their involvement and control over education. The use of ICT will widen the gap between rich and poor and give control of the education system to corporations. She argues that educational administrators, the mass media, and the general public have a “blind acceptance” (p. 100) of information and communication technology and a tendency “toward techno-worship” (p. 102).

Werry (2001) outlines some of the challenges to traditional public education from the corporate, for-profit sector. These challenges are not just from private institutions, but also through the outsourcing of various services such as e-mail at learning institutions, sales tactics used by book publishers, and the increased number of partnerships between public universities and private-sector companies. Rather than resist the use of technology in education, Werry supports “critical engagement” (p. 13) and calls for the development of an open source movement for academic resources similar to that which developed in the software industry to challenge the dominance of large corporations.

Some research related to the use of ICT in schools provides insight and guidance for this research. The Apple Classrooms of Tomorrow (ACOT) project points to the importance of professional development if the use of ICT

is to be successful in schools (David, 1996; Yocam, 1996). After 10 years of the ACOT project, policy analysts were saying that for the use of technology to be successful, 30-40% of the total effort would have to be on training and staff development. In the early years of the project during follow-up visits to classrooms of teachers who had participated in workshops, David noticed that teaching strategies had not changed much. Over time, gradual changes became noticeable. He concluded that to challenge their professional beliefs about practice, teachers needed sustained support and time to adjust to new technology.

Bass and Rosenzweig (2001) provide examples of how ICT can be used in social studies education. They give three broad categories in which ICT can be used successfully in education: in inquiry-based learning as a source of various forms of content; as a communication tool to promote learning dialogues; and as a format to display students' work. They make recommendations about the use of ICT in classrooms including developing a renewed commitment to equality, revised assessment methods, providing teachers more tools and support, enhanced teacher professional development programs, changes to preservice education for teachers, and increased classroom-based research on what works and what does not.

Shaver (2001) notes some of the weaknesses of the Web as an educational tool, pointing out that much of the information posted is unreliable and that many search engines are "closer to slot machines than library catalogues" (p. 18). He also notes several other shortcomings that could limit the effectiveness of ICT in schools: the low number of computers available for students, lack of high-speed Internet access, inadequate software, unprepared teachers, and a lack of support for teachers' use of technology.

Johnson, Schwab, and Foa (1999) describe the changes they have observed in teachers as they integrate educational technology into their teaching. They note that some changes in the early stages of adoption involve using technology to complete tasks that have been done in the past. For example, students will be required to write their term papers using a computer. In later stages of adoption the changes are more significant in that they are made in the learning environment, and the tasks themselves change. For example students may be teaching each other and the teacher how to use the technology. Rather than a term paper, students might be asked to gather material and design a Web page. They have found that as teachers move past the early stages, the nature of the classroom changes and students have more involvement in curriculum and assessment decisions.

This review of the literature illustrates the variety of opinions on the value of ICT in educational environments. Given the lack of consensus in the scholarly literature on the value of ICT and given its early stages of use in educational environments, it is useful to examine what is being done in one school.

#### *Methods*

A qualitative case study research method was chosen because it would provide thick and rich descriptions of how these changes are being experienced by teachers. In the early stages of using a new technology, it is helpful to use an open-ended research method that allows unexpected findings to emerge that might otherwise be missed. By examining in depth what is happening at a

leading school in this area, I was able to gain insight into the effect that this technology is having on an individual school and the teachers who work there. The findings presented in this article are drawn from a broader study of the effect of information technology on teachers' work at the high school level.

The school was selected to be studied because of its reputation as a leader in the application of information technology in teaching across the curriculum. The school's staff have won many awards for leadership and excellence in education. Conversations with officials in the Provincial Department of Education and members of the Faculty of Education at Memorial University of Newfoundland also confirmed that this school was a leader in the area of information technology. The school has 38 teachers and offers grades 10-12 to 650 students. With the permission of the School Board and Principal, written requests to conduct interviews were made directly to all teachers at the school. Thirteen teachers from various subject areas responded to the request, and interviews were conducted in person in the school at a time suitable to the participants.

Before conducting the interviews, a review of literature on this topic was undertaken, and several potential areas for investigation were identified. These areas were incorporated into major categories that were then used in the interview protocols, in the analysis of the data, and finally in the presentation of findings (see Appendix). The semistructured interviews lasted from 45 minutes to one hour. I transcribed all interviews verbatim, then coded them by categories used in the interview protocols and other categories that were added as a result of information gathered from the interviews. The preliminary research questions and related literature provided guidelines for data analysis; however, flexibility was maintained in order to accommodate any unexpected findings as suggested by Marshall and Rossman (1999). Further categories were developed by close examination of the transcripts to identify patterns and themes. As the coding continued, categories continued to be refined. During the process of interviewing, transcribing, and refining the data, analytical memos were written to help facilitate the analysis as suggested in both Maxwell (1996) and Glesne and Peshkin (1992). As the data analysis progressed, I began theorizing and exploring implications of the data. A summary report, which included a copy of quotations used, was compiled so all teachers could verify the findings, and all those who were directly quoted were given the opportunity to read the section in which they were quoted to confirm accuracy.

### *Findings*

Teachers gave many different and specific examples of how technology had changed their work.

#### *Changing Teaching*

One teacher explained that the use of ICT made a dramatic change in his teaching:

I used several different things; the Internet is one. I make my own Web sites for people to use, so I have been using that to take my curriculum and present it in a way that is most useful for me. So I design my own stuff because I find there is nothing out there made just for me. So you can make your own and it is fairly easy and I've used it fairly successfully to do a couple of things and I am continually expanding upon that.

This is a trend that he hopes to continue next year by offering one course almost entirely as a Web-based course. The teacher says that many things can be done through a Web site, from giving students notes, which he says is a "low end thing," to having students create their own Web pages. Another use he has found is using a Web site to enhance an actual field trip.

I have a field trip that I do online. It takes them through a field trip to the intertidal zone before they actually go there. So they see all the animals, all the stuff we are going to do there, and it makes the trip run more successfully or more smoothly. We go to the intertidal zone and do exactly what I have been training them to do with the Web site.

The Web site introduces students to the animals and tells them what they will be doing while on the field trip. It shows them techniques they can use to analyze the ecosystem and record the data. The teacher explained that this type of preparation is important because the real field trip is scheduled for a one-hour period, and this would not be enough time to teach students what they need to know to make it productive. To get the most out of the trip, "they have to go out there and know it and go out there and just do it." The prior preparation through the Web site helps students to benefit from the actual field trip.

Some teachers use ICT in preparing material for class. For example, one teacher used a video camera and taped material for students to use for various projects. Also, because the material available on CD-ROM and other formats is of poor quality or does not meet the classroom needs of teachers, some teachers repackage existing material, customizing it for their class.

Stuff you can make yourself is always better, I think, and if the students make it and they make it from dissections and stuff like that ... from the field trips that they do, you know, as far as I am concerned that is the way to go.

In the future, this teacher aims to increase the use of the Internet as a teaching tool by doing some videoconferences and undertaking projects with other biology teachers and students from around the world. One of his ideas is to create a biome Web page where students from other countries contribute pictures of their neighborhood and their surroundings. Students from this school could post pictures of icebergs, the intertidal zone, and the Taiga to show the uniqueness of their part of the world, and students from other countries could e-mail attached files of their environment.

Several teachers mentioned that they used Power Point and other computer programs to improve their presentation of material to class. One teacher explained that by having specific technology, the teacher can deliver more materials to students. Another noted that the delivery of material in class eliminated several basic problems faced by teachers who rely on the use of chalkboards such as poor handwriting, poor artistic skill, contrast, lighting, and visibility. The issue of being able to see and understand the notes is also taken care of, and also classroom time is saved because information is prepared before class. One teacher noted that the technology does not let teachers skip or omit any of the concepts; it just helps them introduce new things, and time is not wasted drawing graphs or diagrams. Noting the importance of keeping students inter-

ested, this teacher said he had always tried to come up with a good presentation product and that technology is part of this.

So if things are well laid out, if things are eye-catching, if things are colorful, it makes a huge difference, and the classic example is—I know you remember—watching a professor draw, draw like a galaxy. How meaningless is that, to draw a galaxy with a stick of chalk? I mean, that just doesn't cut it. Then, to see the best picture we can come up with of a galaxy, today's picture, like what M100 looked like today for the shuttle—from the space telescope rather—you can't get a better picture than that.

Another teacher makes extensive use of software programs to help teach physics. The students use Verner software and conduct 90% of their labs using computers. The students go into the laboratory and collect their data using the computer. Then they use word-processing programs along with Excel to do graphs and presentations. The software allows the students to collect different kinds of data using various attachments that are plugged into the computer. Using computer technology, students have more time to explore beyond the mechanics of counting dots and setting up the experiment. It lets them look at it and understand the concepts better.

The students get into, you know, dropping objects down through the photo gate and "What kind of graph does that produce?" as opposed to, "If we slide it along the surface of the bench, using surfaces that have more or less friction." [This] gives them the freedom to do a lot more because if I had asked them, using tickertape, to do different surfaces, you know, "drop it, speed it up, slow it down," it would take them about four class periods to do it.

The use of computers is seen as allowing students to get into more meaningful work and it takes away the tedious tasks, freeing time to concentrate on what the content means.

Another teacher made the point that resource-based teaching or resource-based learning is almost becoming "seamless, almost natural" in everything that teachers do because information is becoming easier to access. Teachers and students can do research themselves, and they can set up Web sites where they can build a collection of items, making it easier for teachers to direct students in the research part of the subject area. This teacher thought there was still much potential yet to be developed in relation to the use of Web sites in teaching. He explained that he already puts tests and homework online and archives them so students can go back a month or two later and look at them. The teacher points out that there are many advantages to putting information online: the storage is there for as long as it is needed, access is easy, and material can be updated faster than with most other media.

An enterprise education teacher pointed out that many resources were available on the Internet for teachers and students. Students use Web pages from various career centers to help with preparation of résumés, development of personal skills awareness and skill sets, preparing personal inventories, and writing cover letters. Also, in preparing classes, it was noted that the Internet reduces the time and effort required to gather resources from various banks and government agencies. Because of the ease of access, the variety of information available to students is much richer.



### *Changing the Teaching-Learning Relationship*

Teachers reported that the relationship between teacher and learner is sometimes reversed with regard to information technology. Many teachers mentioned that they had students show them how to use technology. One commented that when students could help teachers, it gave the students a big confidence boost. Some teachers went as far as to use terms like *co-learners* to describe the new relationship between teacher and student.

A French language class in the school had recently held some videoconferences with a class in France, and indications were given that this was something that many other teachers would like to pursue. A member of the administration noted that the school was to partner with two other schools in the province to explore interactive video related to art, theater, drama, public speaking, and other areas.

One teacher described how the use of ICT was enhancing local content. By creating his own material for class the teacher was able to use local examples of animal classifications used in biology. By putting local examples on a Web site, he believed it was more meaningful for students than looking at strange examples in a textbook published elsewhere.

Other teachers felt that the Internet made the world a smaller place, and the idea of a global village was mentioned by several teachers. One said she thought the students did not have a good understanding of their local environment. She said many of them would not be able to pick their hometown out on a map of the world. She thought students should have strong roots based in history, geography, and social studies related to their local area before they started to look at the globe.

Many diverse and interesting views were expressed about the students' need to socialize versus use of forms of online interaction in virtual environments. Teachers saw the potential for technology to be isolating and realized that classroom and other activities had to be arranged so as to reduce the isolating possibilities of one student and one computer screen. Many teachers explained that they usually used technology for teamwork.

Another point was that the use of new technology may increase socialization in some ways. People may be able to find someone with similar interests to converse with through the Internet. Some teachers expressed the opinion that even if the communication is totally online where there previously had been none, then it was good. One teacher seemed to have mixed feelings about this, saying that students who do not socialize much are always a worry, but noted that even when these students are not using computers they are alone and not socializing.

One teacher recognized the situation as a problem and made the point that computers are not unique as a diversion for students.

Yes, it can happen. You know, I see and there are lots of kids, I tell them they need to get a lot more sunshine because they are spending too much time, it is quite apparent that they are spending too much time, with a computer. Still, you know, you can spend too much time watching TV, you can spend too much time reading books, you can spend too much time doing anything, and the computer is no different than any other habit-forming thing.

Other teachers pointed out there is sometimes a level of interaction occurring as students use technology. One student shows another how to use a program or talks about something he or she saw or did using technology. Although the same teacher noted that it was sometimes amazing how silent computer classrooms were compared with a literature class where there is much discussion.

One teacher put forth the idea that using technology in the classroom will mean that training in other subject areas will increase in importance to give the curricular balance needed. The arts and music as areas where students interact will become more important as a means of increasing socialization. Another warned that teachers must be careful when deciding where technology really fits, noting that "some kids have their technological competency very well developed but the rest of their life is a mess."

#### *Administration and Expanding Professional Networks*

The use of information technology has changed school administration in several ways. One teacher explained that when she started teaching six years ago, it was not expected that teachers know how to type their own tests. Now teachers are expected to know how to use word-processors and produce their tests in a proper format. Several teachers noted that there is a move toward total electronic grade-keeping. Next year in this school, attendance will be kept electronically. Several teachers mentioned that this format was much more convenient for them because they did not waste time physically carrying records down to the main school office. Other teachers expressed concerns about the teachers with no or limited technology skills. For them it is a steep learning curve to keep up with such changes. Other teachers see this development as a transfer of work from administrative assistants to teachers, with teachers consequently being busier. Another change noted by most teachers was the change in internal communications avenues.

Teachers are expected to check their e-mail, and many matters that used to be discussed at a staff meeting are now discussed via e-mail. Also, e-mail is becoming an important communications tool between parents and teachers. Most of the teachers use e-mail to keep in touch with other teachers and friends. One teacher explained that she is in contact on a regular basis with a core group of teachers in her subject. E-mail has been useful for activities such as organizing conferences and talking back and forth on various subjects.

Another teacher explained that e-mail is the main way he attempts to keep track of what is going on and to keep in touch with other people in the profession. A third teacher comments on how important e-mail is for him:

I use e-mail for 80-85% of my communications because most of the people I communicate with are as busy as I am and they prefer it. And again it is convenient and you can answer it on your own terms. So, yes, the school I work in has a LAN and everyone here has e-mail and the expectation is that if I send a message I know everyone here has gotten it. I communicate with people regularly in New England, Ontario, Winnipeg. You know, I would be lost without e-mail.

Other teachers mentioned that it would be useful if they could get a list of e-mail addresses for teachers across the province who are teaching the same courses. In some subject areas, teachers were already working with such a list and using it to keep in contact with their peers. For example, through e-mail

learning resource teachers were identifying training needs and pushing to have a workshop created in the area. They also use technology to discuss course content and to see if they can collaborate in developing material. Another teacher who uses e-mail frequently also encourages students to build networks by e-mailing teachers who are experts in a particular aspect of a course they are taking. Two other teachers said that when they were developing courses in specific areas, they used information technology to talk to experts in distant locations and to scan information in the many magazines and journals that are now online. Several teachers mentioned that they were e-mailing people in distant parts of the world for various reasons. The cost of conducting these interactions through alternative means such as a telephone would usually be prohibitive.

#### *Teachers' Concerns About the Use of Technology*

Several concerns related to the use of technology in schools emerged from the interviews. Although recognizing that there were some concerns and problems with integrating the use of information technology, teachers thought that the effort was beneficial to the educational process and should be continued. One teacher put it forcefully:

It is very exciting, its very empowering. The benefits just obliterate any negatives. Right now, in our context, right here, the positives just blow away the negatives. It's not a balancing act at all, it's a blowout.

In the context of this strong endorsement of the use of technology, it is important to look at some concerns raised by teachers that could lead to their resisting the use of information technology.

*Maintenance.* When asked about potential problems that they thought might arise from the use of information technology, the problem most often noted by teachers was the maintenance of the equipment needed to operate a technologically enhanced school. One teacher expressed amazement that the school staff had maintained the information technology infrastructure used in the school. He explained it had been made possible through the dedicated work of personnel at the school who had accepted responsibility for it and their hours of volunteer time. However, he stressed the necessity of finding a new approach to maintaining the infrastructure, noting that a business with 200 computers online would have three or four full-time technicians.

*Inequalities.* Another frequently mentioned problem was the disparities between students who have access to computers at home and those who do not. In this regard, one teacher thought schools were presently in a transition stage where students are starting to get more access to computers, but the point has not been reached where all students have access whenever they need it.

*Need for training.* The findings of this study support the importance of professional development for teachers to use technology successfully. Teachers were not happy with the poor availability of outside opportunities to get professional development in information technology. Courses to meet teachers' needs were either not available or too expensive. Teachers acknowledged the importance of the efforts in school to promote professional development in integrating information technology into classroom teaching. The professional

development days and the flexible mentor-type training occurring in the school were viewed by teachers as important.

*Information overload.* Teachers recognized that sometimes students are overwhelmed with the amount of information available and with the task of filtering through the information. For example, they predicted that the skills involved in site evaluation would become more important because students tend to accept something as accurate simply because it is in print or because it is on the computer screen. Teachers interviewed believed it was important that teachers and students question the validity of the information on the Internet, and that people have the skills to sort through all the information effectively. One thought that search engines and the organization of the Internet might mature to the point where finding reliable information could be made easier in the future.

*Pace of change and stress.* One teacher commented on the pace of change and the fact that technology is moving so quickly that teachers have difficulty keeping up to date. Another commented on the increasing stress level, in part caused by technology.

You are in a very rapid changing society. It is very stressful. People are stressed. Families are stressed. It is that things are just coming at you so quickly, and people expect you to be almost superhuman.

It was felt that this level of stress is being transferred to young students. The teacher pointed out that some students, even those in elementary school, have schedules that include sports, advanced courses, and other extracurricular activities that give them little time to play.

*Plagiarism.* One teacher raised the issue of increased plagiarism because technology was making it easy to reproduce and revise someone else's work. She also felt that sometimes the product looked good because of the technology used to produce it, but the thought and the work did not go into it: "there is a lot of cutting and pasting going on."

*Business involvement.* Another emerging issue mentioned by two teachers, which the public and educators will have to deal with in the future, is the possible loss of control of the education process to business partners. It was noted that the school where these interviews were conducted had more than 150 partnerships. Business partners provided computers and technical support into the school. Although one teacher mentioned this as a positive development, another was concerned about possible negative implications. Balancing the interests of these partners and those of the students might be an increasingly challenging task for administrators as business involvement in education increases.

*Teachers' time.* Teachers stated that information technology was taking more of their time and placing more demands on their time. Teachers noted that extra time was needed to learn new software and also to create new products for teaching.

I need more time for my own development. I need more time to create stuff. I don't have enough time to, you know, the students are demanding, the presentation quality that can be done at high ends with this thing and I don't have time to do it. I don't have time, I wish I had. There are things that I know I can do I don't have the time to do.

One teacher thought that technology would add more time to his day because he could do most tasks in less time, but he finds that he has less time: because his duties require less time, he is expected to take on more.

#### *Conclusion and Discussion*

Drucker (1999) asserts that real change happens only when our mental geography changes. There is evidence that the mental geography of teachers in this school is beginning to change. Although this appears to be a slow process, there is evidence that we may be only at the beginning of what is possible as ICT is used in schools.

The stages of adoption, and the importance of these stages, is discussed above, and it is evident from the research at this school that teachers are at various stages of adoption. Some teachers are using and experimenting with ICT, whereas others are still gathering information. Teachers are in the process of making these shifts and in the process of change, but there is insufficient evidence to view classrooms as obsolete as suggested by Perelman (1992) and Salisbury (1996). Given the state of affairs described in this article, the process of adoption is slower than many of the scholarly writers predict. Compared with some predictions, changes in technology that are occurring may not seem substantial, but if recognized as the initial stages of adoption, then the importance may prove to be far-reaching.

The research reported in this article found less of a dichotomy between implementation and resistance than might be expected. Teachers seem to balance optimism with awareness of potential problems and are willing to speak out about changes they feel are necessary. Although there is some transfer of duties such as typing and computer maintenance to teachers, there are also examples of how teachers' work requires more creativity. The research supports the Apple Classrooms of Tomorrow (ACOT) project findings that teachers require sustained support if adoption of ICT is to occur. Shaver (2001), like many other scholarly writers on this topic, seems to miss the wider issue of how the presence of ICT is changing the relationship between teachers and learners. The changing of the mindset and what it will mean for schools is not dealt with in much of the literature, but the findings of this study indicate that changes in the learner-teacher relationship are starting to occur and will probably continue. The tasks themselves are starting to change at this school and this is important. For example, the amount of information that can be gathered is enhanced, and the task now becomes to analyze or use it more fully.

Several teachers made comments supporting what Postman (1995) and Stoll (1995) have said about negative effects on interpersonal communications and the competing demands for resources in education. Many problems cannot be solved by technology, and such comments should be accepted as a caution about being overly optimistic about technology. We should also be wary of critics of technology who establish unrealistic expectations to point to the faults of technology when the expectations are not met. A different approach would be the critical engagement advocated by Werry (2001).

The use of ICT is changing teaching in several ways. With ICT, teachers are able to create their own instructional material and thus have more control over what is used in the classroom. Rather than deskilling teachers as some scholars (Apple & Jungck, 1992; Noble, 1998) claim, it seems that technology is requiring

teachers to be more creative in customizing their own material. Also, using Web pages to enhance an activity demonstrates that technology can be used to complement other aspects of good teaching rather than replace them. It is evident that involving students in the creation of useful material as a part of a learning exercise is a way to make school more meaningful for students. Although the use of Power Point presentations has been criticized by some, teachers in this school provide examples of how it helps them with their teaching. The use of peripheral devices on computers to help with physics experiments again shows how ICT can be used to aid the learning process and help students focus on higher-level concepts rather than less meaningful tasks.

In terms of changing the teaching-learning relationship, the use of the Internet makes it much easier for students to gather information from outside sources independent of their teacher. It expands the resources that are available to students. The Internet in this way certainly challenges the belief that computers are an isolating or confining medium. The fact that real-world resources are easily available makes learning exercises more realistic for students.

Expanding professional networks and changing administration is another major effect of ICT. The use of e-mail facilitates greater communication among teachers in the same subject area. In smaller schools with few teachers in the same subject area, these out-of-school communications hold potential for an improved exchange of ideas and the creation of networks that are so important in the diffusion of innovation (Moore, 1995; Rogers, 1995). Also, teachers are using or see potential for the use of ICT for professional development. Although some critics of ICT portray it as another mass media (Postman, 1995; Robertson, 1998) the findings of this study indicate that teachers are using this technology to create their own individualized material and reducing their dependence on mass-produced textbooks. This practice may be a new trend in teaching similar to that called for by Werry (2001), which involves teachers developing free-source courseware just as some computer users collaborate to develop software that challenges the dominance of large corporations.

The concerns teachers have about the use of ICT in schools highlight issues that teachers and administrators will have to deal with in the years ahead. Teachers are concerned about the issue of socialization and students being absorbed in a form of virtual reality or suffering from online addiction. This concern has been raised, especially in relation to students in elementary and preschool (Vail, 2001). The concerns raised by teachers in this school indicate that further research on high school students and this issue is needed. This situation mirrors a broader debate about what is happening in society as more communication is done online (Birkerts, 1994; Tapscott, 1998). Another aspect of socialization evident from the research is that in some cases ICT can be used to enhance our experiences of "reality" such as through preparing students for a field trip as described above. Problems of equipment maintenance illustrate how the introduction of new equipment into a school can change the need for technical support. It seems that schools and school boards are still at the stage of discovering and reacting to the new demands that will be placed on them as a result of a more technology-rich school.

The issue of inequality of access has always existed because students come from different home environments and have had access to different learning

resources. The use of ICT has the potential to increase these inequalities. Teachers, schools, and school boards must implement policies and procedures to redress this issue. Some possible strategies could be to provide access to ICT in school outside class time, to sponsor group purchase plans for home computers, or to establish a sign-out program whereby students can borrow computers for home use. This is also an issue of government policy concerning public access to ICT that could be addressed through actions such as support for public libraries and access centers or regulation of private-sector service providers.

The need for training is also a major issue that needs to be addressed. Many studies point to the importance of professional development efforts in the integration of technology. This study confirms such findings, but points to a lack of available programs and support for people wishing to pursue outside training. This study also recognizes the importance of in-school professional development efforts. Teachers were also concerned about information overload and stress caused by the pace of change. Although these are problems with broader societal implications, schools and school boards should examine these issues and try to implement procedures to help both staff and students. A point partly related to this is teachers' time. Although technology helps teachers do things more quickly, the presence of technology also puts new demands on their time. It seems that increased expectations of availability and out-of-class work are being driven partly by the presence of ICT.

The problem of plagiarism has always existed in schools, but the use of ICT adds a new dimension. For example, a number of Web sites and chat rooms exist where students can exchange term papers. Technology is making it much easier for students to cheat and in most cases making it much harder for teachers to catch them. Although anti-plagiarism detection services exist, the use of ICT will probably bring many challenges to evaluation (Reid, 2001). Another challenge for schools in the future may be commercialization. Business involvement has been a major issue at the university level in relation to academic freedom. Although this issue was mentioned by teachers, it was perceived by them to be a potential problem rather than a current problem in the school. Given the significance of the business involvement in the school, it could be an emerging issue at the high school level as well.

Several examples were given by teachers of how technology is being successfully integrated into classroom teaching. This study demonstrates that teachers can use ICT at the high school level to interact on a global basis and expand resources available to both teachers and students. It also demonstrates that ICT can be used to enhance local content in ways that would be more difficult using older technologies of mass production. Another finding of this study is that the changes caused by the introduction of information technology into learning environments are not without some potential problems that must be considered by administrators. The information from this school indicates that some fundamental rethinking of the education process may be necessary because of the use of ICT. This will also put pressure on the school system to restructure how education is organized.

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*Appendix: Interview Protocols*

How has the use of information and communication technology (ICT) changed the work you do?

How do you use ICT in your teaching? Class projects? How has it changed the work you do outside the classroom? Preparation? Grading?

How do you feel about the use of ICT in the school? Has your attitude toward the use of ICT changed? If so, how?

Has the introduction of ICT left you doing things which require fewer skills? Are you doing more menial labour? Are the skills you used as a teacher in the past now becoming irrelevant? Does it require more or less skill? Different skills? Lower or higher level skills?

How did you get the skills to use ICT? Are you using ICT for professional development in any way?

Is the relationship between student and teacher changing because of the use of ICT? Is the professional authority of teachers being questioned and are expectations of teachers changing because of ICT?

Do some students use the ICT as a diversion? If yes, how is this affecting your work as a teacher? Is it distorting their perception of reality or adding to a clearer picture of reality?

*Conclusion*

What concerns do you have about the use of ICT in schools?

Is there anything that I have not asked that will help me understand how the introduction of ICT is affecting your work?