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Technology infrastructure & design : the impact of wireless portable technologies in the elementary school

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TECHNOLOGY INFRASTRUCTURE & DESIGN: THE IMPACT OF WIRELESS PORTABLE TECHNOLOGIES IN THE ELEMENTARY SCHOOL

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Abstract

Alberta Learning created a framework called the Information and Communication Technology program of study, outlining the required use of technology in all core and optional curriculum areas from kindergarten to grade twelve. It is the purpose of this study to examine the use of wireless local area networks technologies and wireless portable computers in elementary schools and to see if these technologies help facilitate more purposeful opportunities for students and teachers to implement the Information and Communication Technology program of studies into all curricular areas. This study is a qualitative, field research project using surveys, interviews and photographs to collect data. The portable lab was found to have a positive impact on both learning and the learning environment in elementary schools. Teachers demonstrated an increased comfort in using technology and were able to collaborate and learn new ideas to integrate technology into the core curriculum. Students enjoyed using the lab, and showed increased motivation and confidence. Due to the mobility and flexibility of the technology, the lab could be used in a variety of schools and classrooms, without being limited by physical space, existing infrastructure, or teaching styles of the teachers. Finally, information technology support and professional development were shown to be an essential part of integrating new technology into the classroom.

Table of Contents

List of Tables

Tables

List of Figures

Figure

Overview of Study

The Alberta Government has required that the use of technology be implemented into all core and optional curriculum areas from kindergarten to grade twelve. A framework called the Information and Communication Technology (ICT) Program of Study was created by Alberta Learning to outline expectations and outcomes of what students "need to be able to do and be like with respect to technology" (Alberta Learning, 2002, Information and Communication Technology, Kindergarten to Grade 12 section, ¶ 1) when they use technology within the context of learning.

> The Alberta ICT program of studies emphasizes technology as a 'way of doing things' – the processes, tools and techniques that alter human activity.... This ICT curriculum provides a broad perspective on the nature of technology, how to use and apply a variety of technologies, and the impact on self and society. (Alberta Learning, 2002, Information and Communication Technology, Kindergarten to Grade 12 section, ¶ 1)

In one district of the Calgary Board of Education, a mobile wireless Local Area Network (LAN) computer lab has been created, to try to address challenges in implementing the ICT program of studies in elementary schools. Access to wireless technology and portable computers for elementary students has also been set up in Strathcona-Tweedsmuir, a private school near Calgary. A case study will be done involving the schools in the Calgary Board of Education, which have been or are currently using the mobile wireless computer lab, and Strathcona-Tweedsmuir. As well, current research from other school jurisdictions and published literature will be used for comparative data. The findings from this research will be used to determine whether

wireless LAN technology and portable computers benefit the elementary school learning environment, and if this technology helps facilitate implementing the ICT program of studies.

Purpose and Rationale

The purpose of this case study is to analyze the impact of wireless LANs and portable wireless laptop computers on the instructional learning environments of elementary schools in the Calgary Board of Education. In this project, elementary schools refers to those schools which will be involved in the case study and represents schools which have students from kindergarten to grade six. Elementary schools chosen for this research represent a fairly typical cross section of elementary schools in the Calgary Board of Education and data collected from these sites will be used for the purpose of extrapolating the analysis and conclusions from this research to elementary schools in general. As new technologies become more powerful and portable it is the role of educators to understand the implications of introducing these technologies into schools and to learn how they impact or enhance the quality of education.

Throughout recent history, computers have become smaller, less expensive, and more readily available to the public. During this technology revolution, it was hoped that technology would change how people created, communicated, analyzed and stored information. The decreasing size and increasing power of computers brought technology closer to many users. Eventually, desktop computers were invented, and were introduced into schools.

The recent inclusion of the ICT program of studies into the Alberta Learning curriculum is meant to encourage technology learning among all grade levels in all core curriculum areas. The ability to support, sustain and meet the curricular expectations of this program of studies has been very challenging for school boards. In the Calgary Board of Education various arrangements of desktop computers have been used, such as labs,

pods or one to four desktops per classroom. This has increased access to technology, has begun to improve opportunities for ICT integration and has been a benefit to students and teachers. However, despite the quality of its technology infrastructure, the Calgary Board of Education is still far from tapping into the capabilities of the technology for all learners.

Now, laptops and wireless technology have been developed to a point where many school boards are considering them as a viable alternative to traditional computer lab settings. The traditional computer lab setting does not always seem to be able to meet the demands for timely access to technology for learning nor has it met high expectations for enhancing student learning and achievement. Educators need to know if the flexibility of wireless portable technologies could have better results in implementing the ICT program of studies and empowering students in their learning over that of the traditional fixed, wired to the wall, large desktop computers.

It is the purpose of this study to determine if the use of wireless LAN technologies and wireless portable computers benefits the learning environments of elementary schools and to see if these technologies help facilitate more purposeful opportunities for students and teachers to implement the ICT program of studies into all curricular areas. The study will examine educators' and students' perceptions of how wireless LAN technologies and portable computers impacted their learning and instruction. The study will collect data on the ability to adapt wireless LAN and portable technologies within existing school infrastructure and instructional delivery methods.

Background

History of Technology

As computer technology has evolved over the years, its introduction and growing impact on the classroom have changed as well. Each change provides new opportunities to reflect on the best practices of how digital tools are used in the learning environment. A review of the history of computer technology demonstrates the growing impact technology has on the classroom and the new teaching and learning methods that have been created.

1946 saw the advent of the first useable computer, the ENIAC (Electrical Numerical Integrator and Computer), shown in Figure 1. The ENIAC was worth millions of dollars, took up the space of a large room, weighed over 30 tons and contained thousands of vacuum tubes, relays, resistors, capacitors and inductors. Because of its size, cost and complexity, it was only accessible to a few people. Those who worked on the ENIAC probably never envisioned today's computing technologies, which are thousands of times more powerful and so small that they can fit in the palm of a child's hand.

From this first computer, the computing technology revolution began. From the 1970s to the present day, the evolution of the shrinking digital box has increased exponentially in computing power and data storage. Big mainframe computers, housed in rooms at universities, government buildings, and large companies, cost hundreds of thousands of dollars to purchase in the 1970s but can be acquired today by the average citizen for less than $500 (Minasi, 1998). The changes in the computer brought about the creation of the Internet, the introduction of powerful software tools and the building of

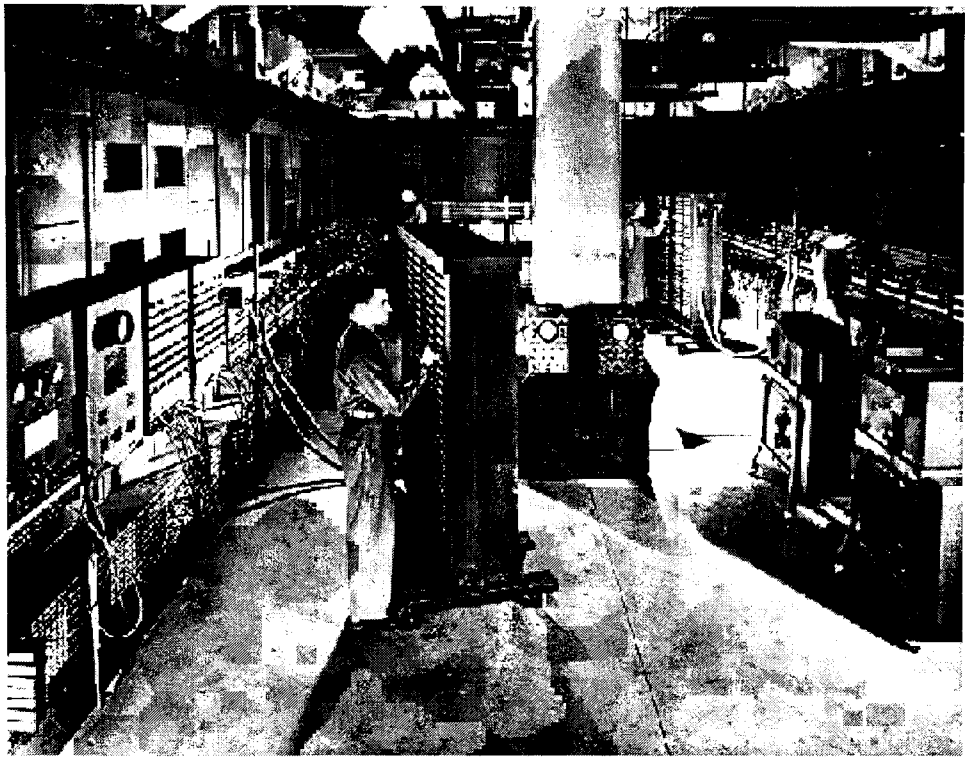

Figure 1. ENIAC computer.
US Army Photo

global communication systems creating an information and communication revolution, all around the world. As the technology became more powerful it began to become an integral part of society's cultural and economic tapestry (Dumestre, 1999; Guterman, 2002). Possibilities for technology applications in all sectors of industry, including education, have increased. Proponents of digital computers began to believe that technology was an integral part of learning. The demand and pressure to have digital technologies in the school systems and curriculum increased as technologies became smaller, more practical and affordable (Oppenheimer, 1997).

In the late 1970s and early 1980s computers began showing up in the K-12 schools for students to explore for the first time. Even though these computers were smaller and more powerful than a mainframe computer, their size, location in the school, cost and complexity still made them inaccessible to the majority of learners within a school. This limited the impact and possibilities for using technology in the core curriculum as the majority of the teachers and students did not have the time or interest to explore the benefits and limitations of computers, as applied to learning, work and play (Becker, 2000).

An increasing desire to find ways to make technologies portable led high tech research labs to the creation of computers that would sit on a person's lap and phones that could be carried in a person's hand. In the mid to late 1990s, many private schools began to encourage or require parents to purchase computer laptops for their children as a part of their learning materials. (Belanger, 2000) Australian private schools were at the forefront of using laptops and in 1996, Microsoft Corporation, in conjunction with Toshiba, began a research study to analyze the impact of laptops in schools. The project

was called Microsoft's Anytime Anywhere Learning (AAL) Program and sponsored educators and other interested stakeholders to research and report findings on the impact of portable computing (Microsoft Corporation, 2003). Due to cost and limitations of both wireless LAN technologies and portable laptop computers, implementation of these technologies was not feasible for many of the public schools at the time.

At the start of the 21st century, technology cost has not remained as large of a barrier for many schools. Wireless technologies, which can connect laptops to networks, have become available and affordable to most schools within the last three years. The wireless LAN technology and bandwidth is still maturing but companies like Apple are selling mobile lab packages priced affordably to extend the functionality of learning, as seen in Figure 2. It is amazing that the ENIAC filled a whole room and had less computing power than today's laptops.

Many schools are advocating that wireless LAN and portable technologies are a viable option in today's schools. This is evident in the recent legislation passed by the Governor of Maine authorizing the purchase of laptop computers for every grade 7 and 8 student in that state (Chaffin, 2002). Another example can be found in the Livingston Range School Division in Alberta. This school board, in partnership with Hewlett Packard, has provided some of its schools with wireless LANs and mobile computers for children and teachers (Livingston Range School Division No. 68, 2002). This project is also symbolic of the direction to have more mobile technology in schools.

Laptops, handheld devices, and wireless computing devices are becoming commonplace in today's society, as the 21st century begins. The acquisition of computers for schools continues to increase as many education stakeholders see the need for

Figure 2. Portable lab cart.

students to be technology literate as "access to information and opportunities is the hallmark of this era" (Wepner, Valmont, & Thurlow, 2000, p. 4). Access to information and the ability to learn how to use it is essential for elementary students to learn in the media rich and digital environments of today's society. The computers today are incredibly powerful, yet accessibility, functionality, cost and purposeful use of computers in learning are considered questionable. However, educators continue to use technology to strive to improve student learning and student achievement.

Related Experiences

As technology evolved, and was included in the classroom in different ways, my life experiences were touched by this evolution. I was able to include it differently in my learning and teaching. From my first experience with computers in a school, as a student, to receiving my own laptop as a teacher, my comfort using technology in the classroom and my beliefs around how technology can be used in learning have grown. These personal experiences provide another perspective to this research and study.

First Introductions to Technology

It was during 1982, if memory serves me well, that a teacher pronounced with great anticipation the arrival of the very first computers at Crowsnest Consolidated High School. I was half way through grade ten when six new Apple II Es arrived in the storage room behind the staff room. With over 300 students in this rural grade nine to twelve school, keen students lined up to have an opportunity to use this new technology tool … mostly for the games. Although the Apple computers were more powerful than the first

ENIAC and could fit on a large desk, it was still a challenge to provide an opportunity for all 300 students to use the technology within existing timetables. The technology did not appear to fit in to existing structures of education.

Administration and teachers made a decision that only the grade nine students would have the opportunity to use them in a more formal learning sense. I remember being frustrated by the fact that the grade ten students could not have access to the machines. "Besides," as one teacher was overheard saying, "it is too late for the older students to begin learning how to use these and they would not benefit from the experience anyways." In reflecting upon this comment later as a teacher, I began to wonder how one could determine when to introduce technology as part of learning? Should it not be determined by student need or cognitive readiness in the learning environment, which could be at any age?

The reality probably was that there were too few computers compared to the number of students and not that it was too late to learn. Eventually, the Math teacher created a computer club after school. I came occasionally but generally could not because of after school athletics. All I really wanted was an opportunity to see what you could do with the new machines but access to the technology made it difficult to realize. I soon lost interest and pursued other high school activities.

During that year though, I did discover a remarkable piece of technology, which was used regularly at school, *a Pair of Glasses*. What an empowering piece of technology; it opened a whole new world of seeing. How amazing it was to discover, at the age of 14, that the teachers' handwriting was clear. By using this new technology, marks improved and greater engagement in learning activities occurred. Imagine if

glasses had the power and functionality of computers and every student had access to her/his own anytime and anyplace. This could change perspectives of the use of technology in teaching and learning in the K-12 schools and provide greater opportunities to remove some individual student learning barriers.

The Opportunity to Think Differently

Mobile computing and wireless LAN technology tools provide an opportunity to think differently about how teachers can "create a classroom environment in which digital technologies enhance rather than diminish learning" (Clifford and Friesen, 2001, p. 31). As technologies evolve they are often designed to solve a problem or question. Their evolution allows teachers in the classroom the opportunity to envision how technology can enhance learning and creatively find new methods and best practices to design productive learning environments that use technology. Throughout my career I have been privileged to work with very creative and talented people who have helped me understand the need for well-designed learning environments and helped me to envision the possibilities of what new technologies could bring to all learners.

In 1991, I started my teaching career and participated in the unfolding of a brand new high school. The architectural design, instructional methods and technology were considered leading edge and teachers were encouraged to push the envelope. The design of everything at that school allowed educators to challenge traditional conceptions of how a high school should operate.

Later on in a leadership role in a traditional high school that was almost 100 years old, the principal asked me to help create an environment of innovative teacher practice

and instructional methods that used technology design within traditional structures. It sometimes felt like "pouring new wine into old bottles". Individuals from both these settings inspired me as I worked with them designing learning environments that used technology. Given the budgets, building limitations and technology standards available, remarkable and innovative designs were created. These experiences helped me develop a philosophy in my career of looking for innovative practices to benefit learners while honoring successful traditional practices.

My first high school had labs that were set in pods, computers in every classroom and wiring troughs in each room. The technology had the ability to expand. I have taught in a variety of settings, labs configured in pods and rows, a math classroom with four computers to share between 28 students, and a marketing and law class where students had to go down to the lab or the library. The science classes had their computers on carts to create mobility from room to room.

Dr Pat Clifford stated during a lunch conversation that the ability to use technology in powerful ways will not occur until it is truly ubiquitous. The word "ubiquitous" was a new term for me. It sent me on a deeper exploration in researching the impact of technology infrastructures and teaching practice on learning environments and a desire to see if wireless LAN and portable computers could help the use of technology in the elementary school become more ubiquitous.

An ICT Specialist Perspective

In August of 2000 I moved from a teaching and leadership position in a large high school to pursue a job in the Calgary Board of Education school district office of

Collaborative Learning Community Four (CLC4) as an ICT Curriculum Specialist. The main responsibility of the work was to help teachers and administrators of 27 schools implement the ICT Program of Study. I was required to find innovative ways to use technology to maximize access, equity and choice in the learning environment.

After meeting with teachers and principals from these schools, I was awed by the excellence in teaching, diversity of needs and incredible challenges for many of the schools that were working towards full implementation of the ICT Program of Study. Through this rich diversity of learning environments, my understanding of educational issues and challenges was broadened, especially at the elementary level where my experience was limited. The opportunity to engage in thoughtful conversations with colleagues of these schools around how to implement the ICT program of studies and to look at the possibilities of how technology can benefit student learning and achievement was a critical component of the work. Engaging professionals to be open to new ways of using digital tools and designing technology infrastructures around how students learn the curriculum is important to successful implementation of the ICT program of studies and empowering student-learning opportunities.

AISI CLC4 Portable Lab

A large portion of my administrative role was to help schools through professional development models achieve success in the creation and implementation of their school goals. Shortly after starting this new position at the CLC4 district office, the principals of the elementary schools asked me to take on a project in November 2000 to

address equity of access to technology. The project was approved as an "Alberta Initiative for School Improvement" (AISI) and was called the CLC4 Portable Lab.

The premise of the project was the following:

- to address equity of access to technology for some of the smaller elementary schools and those with little technology.
- to pilot the use of new technologies (i.e. Wireless LAN technologies and laptops).
- to increase professional development opportunities for teachers through the use of the portable lab.
- to evaluate the impact of using wireless portable technologies on the learning environment.
- to observe how these technologies assist in the implementation of the ICT program of studies.

The portable wireless lab consists of 22 laptops (iBooks), a mobile wireless access point, wireless color printer, color scanner, digital video camera and a digital camera. The lab is scheduled into a school for a two or three month period and is easily moved from one school to another school.

The CLC4 portable lab has provided the Calgary Board of Education with an opportunity to see things differently in relation to the importance of technology infrastructure in education. Over the first school year of getting the lab up and running it appeared that greater equity of access was being achieved. It fit into existing infrastructures with little impact and did not require a school to sacrifice classroom space. The lab appeared to increase the usage of technology in the curriculum, and it was

noticed that teachers' desire to learn how to meaningfully use technology or even use it for the first time increased as well. It was astonishing to see what was being achieved with the mobile lab. Further observations and documentation through this study is intended to benefit other elementary schools and school districts.

A Laptop of My Own

Besides seeing initial observations from starting the portable lab, I received my own laptop for work. It changed how I work because I now have the ability to plug in to the network at any school anywhere in the city, or catch up on some reports on Saturday at my own kitchen table. This is better than driving 30 minutes across the city to get back to a desktop computer at the office. If portable technologies could benefit me in my work then maybe a student or a teacher in the elementary school could take advantage of this technology as well. This is why I am interested in portable, handheld and wireless computing, because I believe it allows us to focus more on the student and the curriculum rather than the technology. There seems to be a great flexibility around these technologies, allowing the learner to use these technologies where they learn, play, investigate, create and explore. More importantly, this can occur at any time of the day and at any location, because the technology moves to where the learner is and wants to be. It is no longer a case of the student and teacher needing to come down to the lab.

Conclusion

The creation of the ENIAC started a technology revolution that has the potential to change learning environments of schools. But, while technology is available, until

teachers and students take the opportunity to become familiar with the technology and use it, it will not have an impact on learning. My ability to use the technologies as they evolved in educational settings depended on a commitment on my part to take ownership of understanding the technology and personalizing its applications. Only then was I better able to stand on a foundation of my own experience, and see the possibilities of how technology could help others.

Literature Review

When a pebble is dropped into a pond, it sends out many ripples. The results of dropping that pebble can be felt and seen in many areas of the pond. Like that pebble, bringing new technology into a school can send ripples through many different facets of the school both positive and negative. Education stakeholders cannot always be trying to keep the "pond" still, but rather need to understand what ripples may be caused by introducing new technologies such as wireless LAN and portable computers. This allows the education stakeholders to be proactive and adopt resources, evaluation methods and instructional strategies that maximize excellence in learning when new technologies are introduced. The rippling effect of introducing wireless LAN and portable computers needs to be studied in the context of existing technology use in elementary schools, equity of access to technology, learning environment design, infrastructure cost of technology, professional development and impact of laptops on learning.

Technology in the Elementary School

"Technology is about the ways things are done; the processes, tools and techniques that alter human activity"(Alberta Learning, 2003, p. 1). Desktops, laptops and other digital devices are the tools that can empower student learning and achievement if used with the correct processes and teaching techniques. Educational or instructional technology can be defined as "a particular approach to achieving the ends of education … the use of such technological processes specifically for teaching and learning" (Ely, 2000, ¶ 1). Therefore, teaching style, classroom management techniques, lesson organization and how students are engaged in the learning process are forms of technology. This is

important to remember when studying the introduction of a technology tool to a school, that the digital technology should not be studied in isolation from the knowledge or process technologies. There should be a purpose for the introduction of a new technology in elementary schools; technology should be "the innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs" (International Technology Education Association, 2000, p. 242). Being able to understand how elementary students learn, to know their educational needs and then being able to create, modify or apply best practices in teaching when working with young people is paramount. It is not the technology tools alone then that must be studied but the knowledge, processes and techniques that are employed when using digital technologies that determine educators' ability to meet educational goals.

However the lack of understanding of what technology is by definition and the role technology tools can play in the learning process for elementary students has created a debate around the presence of technology in elementary schools. What fuels the debate is when opponents to technology in the elementary school see the "fundamental question of what these machines are good for going unsettled for the past two decades" (Clifford & Friesen, 2001, p. 31). Kao and Wedman would support that many of our education innovations, such as the introduction of computers into classrooms, fail or appear to fail to make a difference in the learning process because the relationships between the technology, the organization and the people have not been taken in to account (as cited in Buck, 2001, p. 77). Ironically, this debate is occurring when technology is so pervasive in our society and the ability to use it a valuable attribute for Canadians to compete in a global economy (Harder, 2001). "The public generally agrees that for children to

participate socially, economically, and politically in this new and different world, they must acquire a certain level of comfort and competence in using computers" (Shields & Behrman, 2000, p. 3).

Too often education stakeholders focus questions on the technology and not enough on why, where, when or how students might use technology. This gives ammunition to those who oppose the use of digital technologies in elementary schools. Neil Postman, author of *Technopoly*, and Alice Armstrong and Charles Casement, co-authors of *The Child and the Machine,* thoughtfully point out compelling arguments against the use of technology in schools. They focus on lack of training for teachers and improper funding for technology in many public education schools as the main arguments for the belief that digital technologies are not appropriate for elementary students (Armstrong & Casement, 1998; Postman, 1993). The ripple effect technology can have on small elementary schools' budgets and the instructional changes that need to occur when introducing very powerful tools into the classroom can be hard to sustain. CEO Forum (2000) found that the "most disadvantaged schools often struggle against inadequate infrastructure and an insufficient electrical capacity for computers, let alone high speed connections and networks" (p. 28). When the playground project is put on hold to purchase desktop computers for the elementary schools, opponents question what is happening to the value of students playing in sandboxes and finger painting. Is it all to be replaced by digital sandboxes and digital finger art? "Research has shown that many of children's best learning experiences come when they are engaged in designing and creating things, especially things that are meaningful to themselves or others around them" (Papert, as cited in Chen, Healy, Resnick, Lipper, & Lazarus, 2000, p. 3).

Beside teacher professional readiness to using technology tools in the classroom and implementation cost, opponents state that computer tools are not appropriate for children's learning and see the younger children as targets of the corporate or "adult agenda" to create brand loyalty and influence future digital technology purchases (Armstrong & Casement, 1998, p. 54). One researcher questions whether computers improve the quality of instruction in schools, or whether they are "a way of killing thought at an early age" (Drake, 2001).

Many opponents to technology use in elementary schools focus on the computer itself, and in their current state the machines do have limitations, budgets are tight, and expertise in sustaining the technology learning environment varies from site to site. However, technology has been demonstrated to be useful in helping students learn (Becker, 2000; Bennett, 2002; CEO Forum, 2000; Rockman et al., 2003; Valdez et al., n.d.; Wilson & Peterson, 1995). But what is needed to make it work, and at what cost? To say there should be no technology in the elementary school is like saying we should not hand out glasses until you need bifocals.

Does wireless portable technology overcome some of those limitations and are there benefits of this technology and the ways it can be used in teaching and learning that would resolve some of the critics' concerns? Wireless LAN technologies and portable computers should not be the focus of education reform, but rather to look at how wireless and portable technologies can assist educators in a renewal of learning. Some researchers say that learning should be a social activity. "Young students should not sit in front of the computer for hours at a time! They need experiential learning opportunities through hands-on use of manipulatives, collaboration, and cooperative group interactions"

(Vojtek & Vojtek, 2001, p. 68). As well, they "consider it important to give children a broad base – emotionally, intellectually, and in the five senses – before introducing something as technical and one-dimensional as a computer" (Oppenheimer, 1997, Hypertext Minds section, ¶ 3). The current design of technologies in Calgary Board of Education elementary schools with desktops computers and labs does not facilitate this that well. Wireless laptops remove this barrier and allow for great opportunities to collaborate in children's spaces, as described by Swain & Pearson (2001):

> Placing computer equipment solely in labs has been a major obstacle.... Ideally, schools want both computer labs and networked computers in classrooms so the technology becomes a ubiquitous part of the school environment. Allowing students to have access to computers throughout the day can help promote the use of technology becoming a seamless part of the learning process. (p. 11)

Equity of Access

The ability to find ways to create equity of access to quality technology tools and education professionals who have the technology processes and techniques to use these tools in a classroom setting is the challenge of all education stakeholders. How equity of access should be achieved is highly debated as various definitions of equity of access exist and are interpreted differently. A working definition for this study is taken from what the ICT team used in the Calgary Board of Education. "Equity of Access in Information and Communication Technology is the ability of all schools to provide students and teachers with adequate resources, both hardware and software and training through staff development, to enable students to meet the Information and

Communication Objectives through effective teaching and learning" (R. Everett, personal communication, 2001).

Computers and technology are integral parts of today's society. "Knowledge workers . . . who create, organize, and communicate information (usually assisted by computers), make up 62 percent of the United States workforce" ("Are wired schools", 1999, p. 1). With such a large percentage of the workforce involved in using computers and technology, there is a demand on education to teach these new skills and maximize the potential of how technology tools, processes and techniques will be used by future generations.

Despite this demand for training a knowledge based society, a recent Government of Canada publication concluded, "Canada is not investing enough in new research and development, and it is not adequately adopting, adapting, or developing new technologies" (Industry Canada, 2003, p. 2). It has also been noted, "most schools fail to teach the skills the new economy requires" ("Are wired schools", 1999, p. 1). This is creating a gap in equity of access to educational and employment opportunities for the young people in schools. This gap is due to a variety of issues that have impacted equity of access.

One of the reasons for this equity gap is that administrators and teachers will not allocate enough time or digital resources for students to develop skills with using technology tools within the curriculum because they are not reflected in standardized testing. Achievement exams and testing do not yet require a demonstration of these skills, and in times of tight budgets and content heavy curriculums, there is less desire to have total access or equity in students using technology tools if it is not measured. Alberta

Learning only recently released ICT assessment outcomes from a draft to a published document. However, government exams do not require elementary students on the grade three and six achievement exams to demonstrate what they have learned in the ICT outcomes. Occasionally there may be a few written questions that deal with technology ethics or technology impact in society.

In the US, a national survey was completed where teachers mentioned that ICT integration into the curriculum was failing because the promising technology practices which tend to focus on higher order thinking skills were not linked to student achievement tests.

> If age-appropriate higher-order thinking skills are deemed important, it would be helpful to include some measures reflecting these skills on state and local standardized tests. Then "teaching to the test" might include more constructivist approaches with technology to promote students' deeper understanding of complex concepts. (Shields & Behrman, 2000, p. 6)

Another reason that schools have not been as successful as they would like in teaching technology skills is that not all children have adequate access to computers at school. In the United States, there are "about 6 to 8 students per computer", with "more than half of all school-based computers [being] old Apples or pre-Windows 95 PC" ("Are wired schools", 1999, p. 3). Statistics Canada (2002) found that "in January 1999, there was one computer for every nine elementary students" across Canada, with Alberta having a ratio of one computer for every seven students (p. 70). The computer to student ratio is a critical factor in successful technology integration, as described by Haugland (2000):

> The ratio of computers to young children is important—at most 1 to 7, preferably 1 to 5. If this ratio cannot be met with the resources available, it is far better to use a set of computers in a classroom for a month, quarter, or semester and then rotate them to another classroom. (p. 3)

A challenge that was noticeable throughout the literature is that student/computer ratio calculations are not standard. While ratios for various schools are easy to find, the description of what type of computer is being counted in the ratio is rarely included. This leads to a possibility of a school with a lot of old or obsolete technology appearing on paper to have a better ratio than a school with newer technology.

Some researchers see laptops and wireless LANs as a way of increasing equity of access to technology tools for students to be able to acquire more skills and have the time needed to explore higher order concepts of applying software tools. With wireless laptops, educators can also "achieve **critical mass** - enough computers to do something worth doing" (McKenzie, 2001, Ease of Movement section, ¶ 1). Critical mass means that more teachers and students now have the opportunity to use the technology because of the flexibility of wireless LAN technologies and portable computers. A current classroom configuration may have one to four computers available for teacher and students to use. Wireless and laptop computers allow you to create a one to one computer ratio when it is needed and in the appropriate and needed learning locations.

In many studies, most elementary children do not get enough time on the computer to develop a strong enough skill to take them past entry level to innovation (Armstrong & Casement, 1998; Ba, Tally, & Tsikalas, 2002). Part of this is the limitation of fixed computers in labs or a few computers in a class. Physical space and the ability to

place more computers in an elementary classroom become problematic. Studies show that some students get as little as 10 minutes per week on a desktop machine, where it is recommended that a student needs at least 30 minutes per subject, per day in order to see significant educational gains (Armstrong & Casement, 1998; Meredyth, Russell, Blackwood, Thomas, & Wise, 1999).

Schools that have adopted wireless laptops and researchers who have studied their impact have noticed an increase in the number of minutes children can have access to technology tools because they can be placed in schools around how students learn and how teachers interact with their students (Becker, 2000; Smerdon et al., 2001; Rockman et al., 2000).

The math is simple.

If 25 elementary students need to spend 8 hours each on their writing project, they require 200 hours of computer contact time. 5 computers provide 125 hours of contact time per week if used 5 hours each day during a five-day week. It will take two weeks for these students to complete their one assignment if all five computers are used almost constantly.

But many teachers will not allow students to use computers all day long. While they are teaching math and other lessons, they may demand the full attention of the entire class. During this time, the computers sit idle.

In contrast, a laptop cart with 15 computers would provide the 200 hours in five mornings so two teachers could switch the cart from room to room and finish the writing in both classes that week. One teacher does writing in the morning. The other does writing in the afternoon. When they need to do other

> tasks, the computers leave the room and go next door where they will be used without pause for the rest of the day. (McKenzie, 2001, Ease of Movement section, ¶ 8)

Budget is another area that affects access to computers, as most schools cannot afford to give every child a computer. It is important to evaluate if a school would get greater educational use out of 30 laptop computers in mobile carts compared to 30 desktop computers, which are fixed in one classroom or other location in the school. Elementary schools can spend large sums of budgets on technology and yet have many of the machines sit idle. Why? Would portable wireless help solve those problems? Jamie McKenzie (1999) seems to think so in his comment from one of his published reports where he says:

> Moving computers where they are needed and wanted allows a school to cut its hardware budget in half while slowing down the purchasing and replacement cycle. Instead of installing 2-3 computers per classroom that will be used (maybe) 15% of the time, the district cuts its order for 2000 computers down to 1000, invests heavily in professional development and realizes 85% utilization by moving the equipment to where it will be welcomed (and used).
>
> One week here. One week there. Movement spawns use! (Strategic Placement section, ¶ 5)

Another challenge is that teachers do not have adequate access to technology tools or training in order for them to teach the ICT outcomes and integrate technology into the curriculum in meaningful ways.

> We hope many school administrators have come to realize that the occasional technology workshop is not adequate training for teachers to develop the skills they need to use technology effectively in their classrooms. Teachers need opportunities to use technology during the school day with their students, working on actual curricular units. (Tiene & Luft, 2002, p. 57)

To improve teacher to computer ratios, a foundation was set up in the US to acquire laptops for teachers, the Laptops for Teachers Project. The research discusses computer ratios for students but often leaves out the staff and it appears that the students have more access to technology than the teachers do. Some schools have made efforts to put a desktop in every classroom for the teachers or deploy some to the staff room, but many do not. "The number one barrier to [technology] use is the fact that computers are not located in the classroom" (Tyner, 2000, chap. 1). "Teachers [are] generally more likely to use computers and the Internet when these technologies [are] located in their classrooms than elsewhere in the school" (Smerdon et al., 2001), they tend to be used more for mark and attendance entry than curriculum tools. If a teacher is lucky enough to have a desktop in their room, they have to compete with the students to use it. Teachers tend to use the computer more before school or at lunch not during class time. Researchers are noting that if each teacher is given a laptop there is greater use of technology in the curriculum (Falba, Grove, Anderson, & Putney, 2001; Weast, Parry, & Peterson, 1993; Phillips, Bailey, & Fisher, 1999). Strathcona-Tweedsmuir and other private schools in the Calgary area have found that for ICT integration to occur it was necessary to get technology into the hands of the teachers. They found that the flexibility of the laptops allowed them to take it home, and if they had access to a wireless LAN

they could use technology tools anywhere in the classroom or school. A government program in England, with the goal of providing teachers with computers, found "74% of respondents believe that their personal ownership of a computer has a quite substantial or greater impact on their pupils' use of ICT in their schoolwork" (National Grid for Learning, 2001, p. 4)

Learning Environment Design

In order to help facilitate the implementation of the ICT program of studies, elementary schools in the Calgary Board of Education have needed to design learning and instructional environments that provide technology access to learners. It sometimes appears that the technology is driving educational goals and learning environment designs instead of educational goals and best practice of how students learn driving the designs of technology (Clifford & Friesen, 2001). Quality instructional designs that empower learners need to be built around the variety of teaching strategies that are needed in order to meet the educational needs of all students.

> The design of a teaching/learning environment suggests assumptions about the teaching and learning process. When you walk into a classroom with only the basic blackboard and, possibly, sound amplification, the assumption is clear: you can teach whatever concepts and provide whatever information is necessary with the lecture, chalkboard and discussion. Master classrooms take a different starting point. They begin with the assumption that different teachers may prefer different teaching styles, that different concepts may require different media and methods of communication, and that different learners have different cognitive styles. (Conway, 1996, p. 2)

To achieve a master classroom, there is a need for all education stakeholders to have more input in the design issues of implementing technology in the curriculum. Too often, the full implications of what is expected to be gained from the use of the technology in teaching and learning and how the learning environment should be designed are not considered. "When computers were first introduced to classrooms, reformers focused on the innovation – computers and software. They gave little thought to how technology would integrate into instruction and influence assessment" (Sandholtz, Ringstaff, & Dwyer, 2000, p. 256).

The research notes that the limitation of the number of computers, location within the school and amount of time to access the technology caused many of the learning environments that use computers to be designed around the technology rather than around how students learn (Sampson, 1998).

> Instead of allowing for ubiquitous access to digital technologies throughout the school whenever learners need them, decision-makers often arrange computers in laboratories much like individual desks in classrooms.... One explanation for current lab designs can be found in the early days of computers in schools – computers were expensive.... Today, even though computers have dropped in price, are easier to network, have multipurpose applications and software packages running on them, the computer lab scenario has survived as an artifact of how digital technology gets marginalized and deployment options get entrenched in education. (Jacobsen & Goldman, 2001, p. 85)

This demonstrates the need for educators to take the time to understand how the structures, which support new technologies, can be changed to better design the learning

environment to benefit the students. It also seems to infer that more out of the box thinking is needed in the introduction of new technologies such as wireless and laptops, so they are not just used as a computer lab.

The common elementary school computer lab is often set up in a school library, open space of the school or a classroom. Teachers then have to take their classes down to the lab to learn. If teachers could bring the lab or some of the technology tools to the learning environment (students' classroom, playground, fieldtrip) where the student is experimenting, learning, collaborating, would that empower the student's learning in more authentic ways when using technology?

> Students should have anytime, anywhere access to the learning tools they need.... In principle, the work students are doing should guide their decisions about which technology tools they need. Scheduled access to machines should *never* determine what they get to think about. (Clifford & Friesen, 2001, p. 37)

There appears to be a greater opportunity for students to determine how and where they will use technology if they have access to wireless LAN technologies and portable computers rather than the traditional computer labs.

When infrastructures are designed, there is "far too little consideration of movement" (McKenzie, 2001, Strategic Deployment section, ¶ 3). Because traditional labs did not allow for movement, technology usage has been frequently designed around the rigid structure of the lab. This was also a factor with desktop computers, due to their big size and cheaper price. Yet, not all learning occurs in that type of setting. Elementary students use hallways, gyms and outdoor fields as extensions of their classrooms. It is difficult for a desktop computer to go to these extensions of a classroom. "Computer labs

are not the most effective places to place computers.... By placing computers in labs, school leaders are limiting the use of a precious resource" (Hall, 2001, p. 40).

Wireless laptops add instructional flexibility in the classroom and can be used by the elementary student in a variety of learning environments. "One teacher might prefer cooperative learning and teaming . . . A second teacher wants students working solo but facing the front of the room in rows" (McKenzie, 2001, Flexibility section, ¶ 3). The same set of computers can be shared between the teachers, and used in very different settings, allowing the teachers to use the technology to achieve an educational goal, rather than compromising the goal to fit the technology.

"Technology is about giving tools to teachers to teach better" (Trotter, 1999, ¶ 6); it should "enhance learning instead of seeing it as something else that needs to be taught" (Cope & Brewin, 2000, ¶ 4). If the education technology infrastructures are designed more fully to reflect student learning as a central focus, computers could "make a real difference in education," because technology would then be "more personal and a part of the daily learning experience" (Robinson, 2000, ¶ 2).

Infrastructure Cost of Technology

It has been shown by some research that current uses of technology have not benefited classrooms significantly in relation to the cost of implementation and impact on other school programs or resources (Armstrong & Casement, 1998). Others would say that the money spent on professional development, infrastructure, and curriculum development to bring technology in the classroom has had significant improvement in student learning, behavior, and achievement (Apple, 1996; Ringstaff, Yocam, & Marsh,

1996). No matter what side of the issue the stakeholders support, it is evident that it has been a challenge for publicly funded schools to keep up with the changes in technology and provide the necessary professional development that teachers need to make technology integration a worthy educational pursuit. The economic impact has really been felt by many elementary schools (Froese-Germain, 1998). In relation to this research it is important to anticipate the economic impacts of newer technologies such as wireless LANs and laptops for the educational stakeholder groups.

Investment by Stakeholders

Throughout Canada and the United States enormous amounts of money have been and still need to be spent on placing technology in schools (Office of Technology Assessment, U.S. Congress, 1995; US General Accounting Office, 1995). In order to meet the outcomes of the ICT program of studies in Alberta, significant dollars have been invested by the province and school boards, including "an additional $40 million over ... three years to upgrade and expand the educational technology available to students" (Government of Alberta, 1996, p. 1). This funding assistance from the province and district level boards is only partially sufficient in providing technology tools and professional development needed for schools in order to carry out this curriculum. The government acknowledged that a short come of funding exists by stating that "technology integration must be a shared investment by the province, by school boards, and schools, and by business partners" (Government of Alberta, 2003, Investing in our Future section, ¶ 2). For the last three years, Alberta Learning has allocated a Technology Integration Fund at $41/student, incrementing by $1 per year. That program will cease for the next

school year. However, expected costs per student for technology integration range from "$300 per student" (Coley, Cradler, & Engel, 1997) to "$2000 per student" (Becker, 1993). This leaves a large shortfall or gap between estimated costs and Alberta's actual expenditures.

The economic burden of this curriculum appears to become the primary responsibility of the elementary school community. They then begin to look for a variety of ways to acquire resources to achieve the outcomes of the ICT program of studies.

> Schools have funded technology enhancements through Technology Integration funds from the provincial government, successful applications to the province's Alberta Initiative for School Improvement (AISI), lottery funding and in some cases, volunteer fundraising efforts by parents who put a priority on providing their child's schools with more or newer computers. (Drysdale, 2002, p. OS7)

High schools have an advantage in raising funds over elementary schools, as they tend to have greater access to partnerships, "pop machine money", full time technical support and other funding grants. Private schools also have great ability to increase tuition fees or require that students come with their own technology tools. Even where there is good funding available for technology tools at the elementary level, technology support is often only available through "a remote central district office--or they expect tech-savvy teachers to do double duty as in-house experts" ("Are wired schools", 1999, p. 6).

Additional Fundraising

The Alberta Government has helped with some initial capital purchases, but is their funding sufficient to sustain the mandated implementation of the ICT program of studies? With such challenges to acquire and support technology assets in sustainable ways, even avid proponents of technology in schools become frustrated and question the value of technology at the elementary level relative to other costs of running the school and the basic educational programs.

In the movie, "The Ten Commandments", a taskmaster told the Israelite slaves that they would have to supply their own straw to make bricks for Pharaoh and would be required to make the same amount of bricks. Are elementary schools asked to do a similar thing, as the children of Israel in the movie "The Ten Commandments", and build a learning environment that infuses the use of technology into all curriculum areas [bricks] without having sufficient digital tools and supports [straw] supplied?

To make up the shortfall opponents would say that many schools have been scraping money together at the expense of other important programs or needed resources for schools and students. Introducing technology to schools has the effect that "other ways of doing things are sacrificed" (Franklin, U. as cited in Froese-Germain, 1998, p. 2). It is documented that school positions such as teacher librarians are cut and other optional curriculum areas disappear in order to afford and make room for the computer labs (Alberta Teachers' Association, 2001; Chen et al., 2000). "Concerns have been raised that arts, music and other programs are being cut to accommodate technology" (Froese-Germain, 1998, p. 2).

In addition to finding funding for the technology resources or paying for technical support there is an "increasing dependence of schools on corporate partners (which) should raise concerns amongst educators" (Taylor, 1999, p. 8), especially if corporate logos or daily commercials end up appearing in schools to create brand awareness and loyalty.

What is more disturbing is the expectations placed on public school educators and tax paying parents to make up the funding shortfall by raising money through grants, casinos, lotteries or fundraisers. Bilan (1999) concurs that "parents still need to raise funds to purchase computer technology that the business community has made fundamental to its success in the last 10 years" (p. 37), which creates equity problems from school to school. In the Calgary Board of Education, ICT specialists were often asked to write letters of support for schools councils applying to the "Lottery Board for Funding" in order to finance technology improvements. All this has become necessary in order to evergreen or expand the technologies available to students so they can meet the outcomes of a mandated ICT program of studies. "Keeping up with changing technology is almost an impossible task for schools with limited funding" (Alberta Teachers' Association, 2001, p. 1).

Design Economics

Current uses of desktop computers, peripherals and wiring have significant impact on budgets by affecting the instructional design of areas, classroom size and use of technology.

> The desktop computer ended up taking up too much space - dedicated space. Instead of entering the classroom like one more tool for daily use, it demanded special treatment. Ironically, this special treatment usually meant setting the equipment apart from the rest of the room. In many classrooms, the computers are off to one side. (McKenzie, 2001, Cleanliness section, ¶ 3)
>
> Will wireless LAN technology and portable laptops reduce the economic impact? Unlike their desktop cousins, wireless laptops are quite small. They have a tiny "footprint" compared to desktop units. Because they take up very little space, they can sit down just about anyplace in a regular classroom without any special provisions being made. (McKenzie, 2001, Ease of Movement section, ¶ 11)

Because of this space saving, classroom space does not have to be limited to allow for access to technology. Clifford and Friesen (2001) also discuss ways that wireless laptops can fit into current school space, by placing them on existing tables, in libraries, in hallway nooks, in spaces between classrooms, or even in old cloakrooms.

The challenge is helping elementary schools find economical and flexible ways to use technology resources. Despite the best educational designs that use technology, educators will struggle with the costs and time needed in order to provide equitable access for students to develop the necessary skills, attitudes and beliefs about different ways to use technology tools. As technology continues to become more affordable, flexible and powerful, hopefully schools, districts and education stakeholders will be able to redistribute the dollars spent on tools into professional development and other learning resources. This would allow educators the ability and time to advance the process and techniques of using the technology for students' and teachers' benefit.

Professional Development

Technology has changed the possibilities of how teachers work and how students can learn. "Educators recognize the wonderful possibilities of computer use and the potential of new information and communication technologies to transform education in exciting ways" (McFarlane, 2001, p. 3). "Teaching practices must also change" (Wepner, Valmont, & Thurlow, 2000, p. 4) to derive the benefits of what new technologies such as wireless LANs and portable computers have to offer. Educators need to be actively engaged and supported in dreaming and putting into practice the possibilities of how technologies can empower all learners.

Armstrong and Casement (1998) state that there is no need spending the dollars to put technology into schools if technical support is not available and "if teachers do not know how to use it effectively". Tiene & Loft (2002) also encourage that technical support for schools be provided, saying that "one reason many teachers hesitate to use technology is the technical difficulties they may encounter" (p. 19). This can frustrate teachers and impact on lesson time and strategies.

Purposeful professional development is the keystone and one of the greatest challenges to successful infusion of technology across all curriculums. Although it is evident that the majority of administrators and teachers are making gains in taking greater ownership for driving the direction of how technology is used in the curriculum, the education profession still has a lot more work to do and needs to continue to implement strategies for its appropriate use of technology within instruction. "In 1999, approximately one-third of teachers reported feeling well prepared or very well prepared

to use computers and the Internet for classroom instruction" (Smerdon et al., 2001, Teacher preparation and training section, ¶ 2). That leaves two-thirds of teachers feeling unprepared to implement a mandated program.

"Any investment in technology really needs to have an investment in the teachers at the same time" (Trotter, 1999, ¶ 10). Training teachers to use new technology is a crucial step in addressing the need to teach technology skills to students. A lack of professional development opportunities for teachers is eventually detrimental to students, as "a lack of training is the most important obstacle inhibiting the use of digital content" (Fatemi, 1999, Importance of Training section, ¶ 1). Still, the training seems to make a positive difference to those who get it, particularly in their confidence levels, use of digital content, and willingness to experiment:

> Teachers who received 11 or more hours of curriculum-integration training are five times as likely to say they feel "much better prepared today" to integrate technology into their classroom lessons than teachers who received no such training. And teachers who received both basic-skills and integration training tend to feel better prepared than those who received just one type.
>
> Teachers, who received more training of either type, but especially integration training, are more likely to use software to enhance instruction in their classrooms. They are also more likely to rely on software and the Internet in classroom instruction to a "very great" or "moderate" extent.
>
> Finally, teachers with more training of either type are more likely to spend time trying out or teaching themselves about software, and also searching

> the Internet for information and resources to use in the classroom. (Trotter, 1999, Professional Development is Key section, ¶ 7)

The flexibility of having laptop computers for work has given teachers greater access to the technology tools when they need it. As a result, they are able to experiment, learn, create and analyze with the software on the computer more often than if they just have access to a desktop at work (Falba, Grove, Anderson, & Putney, 2001; Weast, Parry, & Peterson, 1993; Phillips, Bailey, & Fisher, 1999). The ability to learn and more fully integrate technology into teaching due to increased time using laptops is echoed in this statement by Tiene & Luft (2002):

> We hope many school administrators have come to realize that the occasional technology workshop is not adequate training for teachers to develop the skills they need to use technology effectively in their classrooms. Teachers need opportunities to use technology during the school day with their students, working on actual curricular units." (p. 57)

Laptops in the Elementary Classroom

"With growing concern over equity in access to technology" (Belanger, 2000, p. 3), and with the hopes of improving student learning and achievement, school districts are seeing laptops as a solution to meet educational objectives. Wireless networks, coupled with laptops, have helped to extend the reach of technology tools to where the students are, providing them with a prospect to determine when and how to apply the tools to use in understanding their own inquiries. In a position paper on technology, the Alberta Teachers' Association warns that the research of the past provides "no clear

connection between the use of technology and gains in student learning" (Alberta Teachers' Association, 2001, Technology in the Learning Environment section, ¶ 1). They do recognize that recent studies where technology tools were used in constructivist classrooms produced positive results, but links this more to "the pedagogical approach used by the teacher" as the "crucial variable leading to gains in learning" (Alberta Teachers' Association, 2001, Technology in the Learning Environment section, ¶ 1).

In recognizing that the pedagogical approach teachers take are technologies as well, what does a review of the literature say about what happens to learning when laptops and wireless are available to the elementary school? There seems to be more emphasis on the laptops and projects students created with software than on the pedagogical approaches used to facilitate the outlook of using the technology tools in innovative ways. There are very few elementary longitudinal studies providing the impact of learning on elementary student achievement and learning. Much of the literature is based on middle and high school studies where inferences to elementary students can be made. However, with the number of elementary schools adopting wireless there are more longitudinal studies being carried out that have not yet reported results. The preliminary research can provide enough information to develop a picture of how laptops are being used, their impact on learning, student responses and teacher perspectives.

How Computers Are Used

As mentioned in the previous portions of the literature review, desktop computers are used in labs and classrooms and can be used for skill building or high cognitive

thinking. The software tools on the computers provide the windows to learning concepts in different ways.

Many articles discuss how students use laptops for a variety of activities, including spreadsheets, research, and presentations (Belanger, 2000; Rockman et al., 2000; Stevenson, 1999; Weathers, 2001). Although many of these projects benefit students and use laptop technology, the same types of projects have been done before with desktops in classrooms or labs by teachers with strong technology backgrounds and pedagogical experience (Ba, Tally, & Tsikalas, 2002; CEO Forum, 2000; Shields & Behrman, 2000). The difference, however, is that the flexibility of the laptops has increased use and accessibility. In schools where students had access to laptops there was a noticeable increase in time on the computer in school and increased computer usage for homework (Stevenson, 1999; Rockman et al., 2000). In addition, students who have their own personal laptops also use their computers at home more (Rockman et al., 2000).

What is unique about learning experiences with laptops is how and where the resources contained on the laptop technologies are allowing teachers and students to work. There is now an opportunity to extend the concept of learning with technology past the walls of the computer lab or traditional classroom. For example, Rhonda Bajalia, a teacher from Crown Point Elementary in Jacksonville, Florida, had her lesson activity of Seaside Science selected as one of 20 examples of effective use of laptops in science and mathematics as part of the 1999 Toshiba/NSTA Laptop Learning Challenge. The lesson required the use of laptop computers on a field trip to the ocean where students classified sea life and shells and produced digital tables and graphs. Other observations were recorded by students as part of their math and science experiments (National Science

Teacher's Association, 1999). The use of the technology to produce tables and graphs was not unique in this case, but using the power of the software tools and technology on the seashore to collect and analyze data was very unique and would provide students with real time analyses. Another example of the flexibility that laptops provide, to allow students to work where they want to be, is provided in the following anecdote.

> The students in Ellen's American history class had just met with me in the library to discuss their upcoming research assignments. Shortly after class ended, Ellen logged on to her laptop computer. She checked our school library's online catalog for holdings on her topic. Then, she conducted a similar search of the Houston Public Library's online catalog, as well as the online catalogs of local university libraries. She also searched Amazon.com, reading its reviews of some of the materials she had found, and hunting for additional titles that might be helpful. Finally, she checked our electronic periodical indexes, on the lookout for relevant articles.
>
> The interesting thing is that Ellen did all this while sitting outside at a picnic table, beside the school. (Weathers, 2001, p. 1)

Impact on Learning

Bringing laptops into the elementary classroom changed how students worked with technology. The size and flexibility of the laptops caused students to be more likely to work together collaboratively than when using a desktop in the classroom (Carter, 2001; Apple, 1996; Microsoft, 2003). Due to increased availability of technology tools, independent learning increased as well (Apple, 1996). How computers were used

changed as well, as computers were used more for learning than for games (Stevenson, 1999).

With an increase in access and opportunity to use laptops anywhere in the classroom, school and, in some cases, at home, researchers found that students wrote more, and their writing was of better quality (Stevenson, 1999; Rockman et al., 2000; Apple, 1996; Microsoft, 2003; Curtis, 2003). As well, math skills and reading improved (Stevenson, 1999), and students showed increased confidence in computer skills (Rockman et al., 2000; Microsoft, 2003).

Student responses

In some studies it was found that the laptops created an excitement and sense of having access to adult tools. In many of the laptop initiatives in elementary schools, student attendance increased, and dropout rates decreased (Carter, 2001; Curtis, 2003; Nacelewicz, 2002). Carter (2001) also notices a positive change in the change in "self-image that disadvantaged students have when they're given the same technology tools being used by their suburban counterparts-and the business world at large" (p. 2). Further, it has been noticed that student behavior has improved, with teachers having to deal with less discipline problems because of the laptops (Curtis, 2003; Nacelewicz, 2002).

On the other hand some teachers have reported that technology tools in the classroom can also be disruptive (McKenzie, 2002). The presence of laptops and other digital devices require teachers to learn and implement new teaching practices, such as having students close the laptop lids when it is necessary to focus on other learning.

In many of the school districts and elementary schools implementing laptops, very few provide or require division one students to have their own laptops. A lot of laptop implementation strategies at 1 to 1 student to computer ratios seem to occur more at the grade five to six range.

Conclusion

Adding wireless laptops to a school will definitely cause ripples. In the literature there is a lot of mention of schools that are currently doing the research, but few results have been shared through peer-reviewed journals, especially at the elementary level.

What needs to be explored is, can the flexibility of portable wireless computers help accelerate support for teachers in acquiring the skills they need to implement the use of technology in meaningful ways through curriculum. It is key for this study to identify the challenges that are providing the roadblocks and develop or create awareness around various solutions. Technical support and access to technology at meaningful times and places are challenges that need to be resolved in schools in order to accelerate the support for teachers. It is important to look at how technology infrastructure can be better designed to support learning environments and the needs of teachers. How can the infrastructure be designed to be more sustainable and supported? The challenge is that technology is ever changing and there is a need to balance somewhere between out of date and the newest technologies. This study will take the findings from the literature review as a base of information to begin collecting data from elementary schools around the impact of wireless portable computers on the learning environment.

Study

Question

Through an action research approach, this project will explore the following question: "Does the use of wireless LAN technologies and mobile wireless computer devices benefit the learning environments and the infrastructure of the elementary schools and does it help to facilitate more purposeful opportunities for students and teachers to implement the ICT program of studies into core curricular areas?"

Methodology

This study will be a qualitative, field research project using surveys, interviews and photographs to collect data. Qualitative research focuses on data "in the form of words, sentences, and paragraphs rather than numbers" (Neuman, 1997, p. 327), which is the case in this study. Perceptions of those involved in the AISI CLC4 portable lab, and changes in the ability to implement the ICT program of studies were the focus of the study, not a statistical analysis of the number of students to use the lab and the number of students who can achieve various ICT outcomes. Rather than having a statistical analysis of lab usage, it was useful to know what changes teachers and students experienced when wireless LAN and portable technologies were introduced to the elementary school learning environment.

The case study was completed in Calgary Board of Education elementary schools, which have had the AISI CLC4 portable lab. These schools are representative of many schools in the Calgary Board of Education and staff at these schools will have been able to reflect on the benefits / limitations of wireless LAN technologies and portable

computers. It is also an opportunity to see if the experience of having access to wireless has helped them address the outcomes of the ICT program of study. The interviews and surveys will give authentic rich context about how useful the lab has been, a grassroots perspective. Part of the study is to analyze the impact on school culture, ways of relating to technology, hoping to identify common themes among teachers/students in a variety of settings.

Data will be collected at a number of elementary schools using similar methods and research instruments throughout the entire study. The main focus of the data collections will be interviews and surveys with teachers and students. As well various examples of technology infrastructure and classroom configurations will be documented through pictures to show the benefits of wireless and portable technology in elementary schools.

Pre and post surveys, which were done before and after the CLC4 portable lab was used at a school will also be analyzed. These surveys contain questions measuring changes in teachers' comfort level with technology and integrating ICT outcomes while the portable lab was in the school. The questions in the survey were designed with a Likert scale, which "provide an ordinal-level measure of a person's attitude" (Neuman, 1997, p. 159), from "strongly agree" to "strongly disagree".

Data collection

Pictures / Maps

Pictures will be used to document how students and teachers are using the wireless lab and laptops. Pictures will also document current school infrastructure and

traditional lab setups in the elementary schools within the Calgary Board of Education. Video / Picture release forms will be given to all participants who are been photographed in order to comply with human ethics research stipulations, Calgary Board of Education policies and Freedom of Information and Privacy Protection legislation (see Appendix A).

There will be opportunities to draw spatial maps when observing how and where students use laptops in their classrooms. Arrangement of students' desks and other physical features will be noted.

Interviews / Surveys

A combination of interviews and surveys will be used. Both the surveys and interviews will ask the same questions. Interviews will be used for students, since it is expected that they will be more capable of expressing their reactions to the portable lab verbally. Principals and key teachers will also be interviewed, to allow them to more fully describe their experience with the lab. Short response surveys will be used for the remainder of the teachers.

The purpose of the interviews and surveys will be to gather rich and in-depth comments about how educators and students have felt when using the wireless portable lab. This would be difficult to accomplish through check box surveys as the interview/survey questions have been designed to allow for opportunities to expand on comments and experiences of the participants. Analysis of the interviews and surveys will allow for identification of common themes among participants. Questions for educators will focus on determining the impact of working with the portable lab through

questions such as "How did having wireless LAN technology and laptops affect your teaching practice compared to using existing school lab or classroom desktop computers?" For further examples of the kinds of questions that will be used, please refer to Appendix B.

Willing administrators, teachers and some students who have been or are currently involved in using the portable lab will be interviewed using videotaping, audio recording, or note taking, or will be given a short response survey. Interviews will be transcribed, coded and participants will have an opportunity to view what was said for accuracy. 6 principals, 15 teachers, and 30 students will be interviewed, and 100 teachers will be given surveys.

Surveys

Permission was obtained from the Calgary Board of Education to use data collected from the AISI CLC4 Portable Lab Project pre / post surveys, which are done before and after the lab arrives and leaves a school. The surveys with the AISI Project include a pre and post survey at each elementary site where the portable lab has been. The surveys reflect attitudes and comfort levels with using technology and implementing the ICT program of studies among teachers who are involved with the CLC4 Portable Lab initiative. See Appendix C for a copy of the pre and post survey and the feedback sheet.

As well permission will be obtained to review any notes, reports, or video / pictures which the CLC4 Portable Lab team has.

Note taking

During visits to the school with the portable lab, memos describing observations that day will be written. There will be opportunities to observe the use of the technology in classroom learning, professional development activities and with students during lunch / after school. An effort will be made to provide direct observation, inference, and analytic and personal notes of these observations. The purpose of this will be to keep track of the researcher's insights, as well as to provide another point of view. Some of the themes that will be addressed are: how the wireless LAN and laptops impact classroom management, comfort with which students and teachers use technology, and change in motivation to use technology in the curriculum.

Much of the literature speaks to the impact of wireless LAN technologies and portable computers on a more macro level in terms of the impact on the school. It is hoped that through open ended questions that a rich source of themes and knowledge can be captured right at the micro level. This will lead to a better understanding of the ripple effect of using wireless and portable technologies in elementary educational settings.

Subjects

The CLC4 portable lab will be at Killarney Elementary School and Hillhurst Elementary School during the data collection period. As well interviews will be conducted with the following five Calgary Board of Education elementary schools that had the wireless portable lab over the last year and half: Briar Hill Elementary School, Capitol Hill Elementary School, Glenbrook Elementary, University Elementary School and Varsity Acres Elementary School. This will provide a rich opportunity to ask

questions around the impact of the wireless laptops, as they have now had to return to their original desktop infrastructures for the delivery of ICT. Data will also be collected at Strathcona-Tweedsmuir, a private school south of Calgary with an established wireless network and access to laptops for elementary students. Strathcona-Tweedsmuir is a private school outside of the Calgary Board of Education, which has had access to wireless LAN technologies and portable computers for the past 2 years. Interviews conducted here will provide longitudinal experiences from the perspective of teachers and students.

A breakdown of the number of people who were involved in the use of the wireless portable lab is shown in Table 1. This provided a framework from which data collection was completed. These sites were chosen because of the different building designs and represented a wide range of socio economic backgrounds. These schools provide good representation of many typical elementary schools in the Calgary Board of Education.

The physical structures of each building will also provide an opportunity to look at the impact of mobility in these environments. Pictures of classrooms, computer labs, and other working areas of the buildings and infrastructure designs of all Calgary Board of Education schools in CLC4 will be used and compared.

Results and Analysis

The main method to be used analyzing the data collected will be successive approximation. Neuman (1997) describes successive approximation as a series of steps, where a researcher "begins with research questions and a framework of assumptions and

concepts" (p. 427), then analyzes responses received, makes any changes required to the questions and assumptions, based on the data analysis, and repeats the process. Initial

Table 1

Wireless Portable Lab Participants

	Students	Teachers	Administrators
Calgary Board of Education Schools			
Briar Hill	189	14	1
Capitol Hill	208	13	1
Glenbrook	248	20	2
Hillhurst	276	12	2
Killarney	215	13	1
University Elementary	392	27	2
Varsity Acres (French)	506	29	3
Private Schools			
Strathcona-Tweedsmuir	200	12	3
Total			
	2234	140	15

data collection will be done at University Elementary. This data will be coded, and the interview and survey questions will be refined. These new questions will be used at Varsity Acres Elementary and Capitol Hill Elementary, and then the process will be repeated. The final interviews and surveys will be used at Briar Hill Elementary, Glenbrook Elementary, Killarney Elementary, Hillhurst Elementary and Strathcona-Tweedsmuir.

Timeline

The case study occurred in selected Calgary Board of Education Elementary schools during the months of October 2002 to February 2003. Major data collection began after formal approval by the following bodies: the Human Subjects Research Committee at the University of Lethbridge; the Chief Superintendent's research office of the Calgary Board of Education and the Head Master of the private school. Data collection occurred between October 2002 and April 2003. March 2003 to May 2003 was used to analyze the data that was collected, and prepare a final report of the findings to be published.

Data Sample

During the course of the study, 15 teachers and 7 administrators were interviewed, as shown in Table 2. As well, 100 surveys were given to randomly selected staff from the participating schools. Of these 100 surveys, 26 were returned for data analysis. In total there were 140 teachers and 15 administrators, giving a 29% sampling ratio for teachers and a 47% sampling ratio for administrators. According to Neuman (1997, p. 222) the

ratio needs to be around 30% in order to maintain an accurate data sample, which does occur in this case. Only 55 out of 491 students at Killarney and Hillhurst were formally interviewed, which is a low sampling compared to the two schools total populations. Students interviewed represented both division one and two of the elementary schools. At these schools, while the wireless lab was present only 403 students (out of 491) used the wireless as part of their instructions. A few teachers decided not to use the lab at the time they were there. While the lab was at Killarney Elementary the school was just starting to implement a Montessori Program at the school and it was the beginning of the school year. This impacted the ability of some teachers and classes to participate in this research project.

The surveys and interviews are summarized in Table 2.

Throughout the analysis of the surveys and interviews, the respondents will be referenced as A1 – A7 (administrators), T1 – T41 (teachers), and S1 – S55 (students).

Table 2

Surveys and Interviews

	CBE Schools		
	Administrators	Teachers	Students
Briar Hill	1 interview	2 interviews 4 surveys	
Capitol Hill	1 interview	1 interview 2 surveys	
Glenbrook	1 interview	3 interviews 2 surveys	
Hillhurst	1 interview	2 interviews 3 surveys	34 interviews
Killarney		3 interviews 1 survey	21 interviews
University Elementary	1 interview	1 interview 4 surveys	
Varsity Acres (French)	1 interview	3 interviews 7 surveys	
	Private Schools		
Strathcona Tweedsmuir	1 interview	3 surveys	
	Totals		
Total Mobile Lab Participants	15	140	2234
Total Sampled	7	41	55
Sampling %	47	29	2

Results

Introduction

The blackboard was introduced into classrooms in 1841 with great reluctance from the teaching community. Many of that time saw the inventor of this learning system as a great contributor to learning and science while others disagreed and tried to block the adoption of this technology into schools. This ebb and tide between proponents and opponents of technologies or systems that could potentially benefit the learning environment of schools has not stopped with the introduction of the blackboard in the 1800s, but has continued on through many societal and technology changes. The television, overhead projector, calculators, computers and now wireless LANs in the elementary school have all been seen as the next tool to change how children are taught and provide them with greater learning experiences. Like the blackboard they have all met with similar resistance and controversy but have, or will in the case of wireless, significantly impacted on teaching practice and student learning throughout time.

It has been suggested that "teachers will regularly use new technologies to enhance their regular instruction but rarely to transform their teaching" (Anderson, C. as cited in Tyack & Cuban, 2000, p. 248) or the learning of their students. Master teachers throughout these times of technology evolution have found ways to use these resources to help students in their academic development. The blackboard did have an impact on the learning environment in how schools were designed and the teaching methods that were employed when working with students.

In analyzing the data from this study it was important to discover if wireless LAN and portable technologies could be used, as the blackboard was, as a tool to transform

teaching and learning. Will they benefit the learning environment and infrastructure of elementary schools and can they help to facilitate more purposeful opportunities for the naturalization of the ICT program of studies in all curriculum areas?

During an initial open coding phase of the interviews, surveys, photographs, and field notes produced during this study the data was categorized under two major themes "learning environment" and "learning". The interviews and survey questions were designed to gather information on the following themes within these two areas:

1. Learning Environment- Learning / Teaching Practices & Methods and Learning Infrastructures.
2. Learning - Professional Development and Student Learning & Achievement.

During the axial coding of the data each theme was further analyzed, defined and coded again which further produce sub themes identified in Figure 3.

Selective coding was then used to find visual, written or oral comments that supported or illustrated the elements of the themes. This data support material will be shared through the report section of the analysis. It should also be noted that through all of the data collection and analyses subsequent key words (Access, Choice, Collaboration, Equity, Flexibility and Knowledge Creation) were present. These keywords were interwoven through the themes, supporting material and the coding system.

The underlining focus in all of the data collected was the implementation of the ICT program of studies and the benefit to learning for students and teachers. The changes in learning and the changes in the learning environment impacted the implementation of this new curriculum.

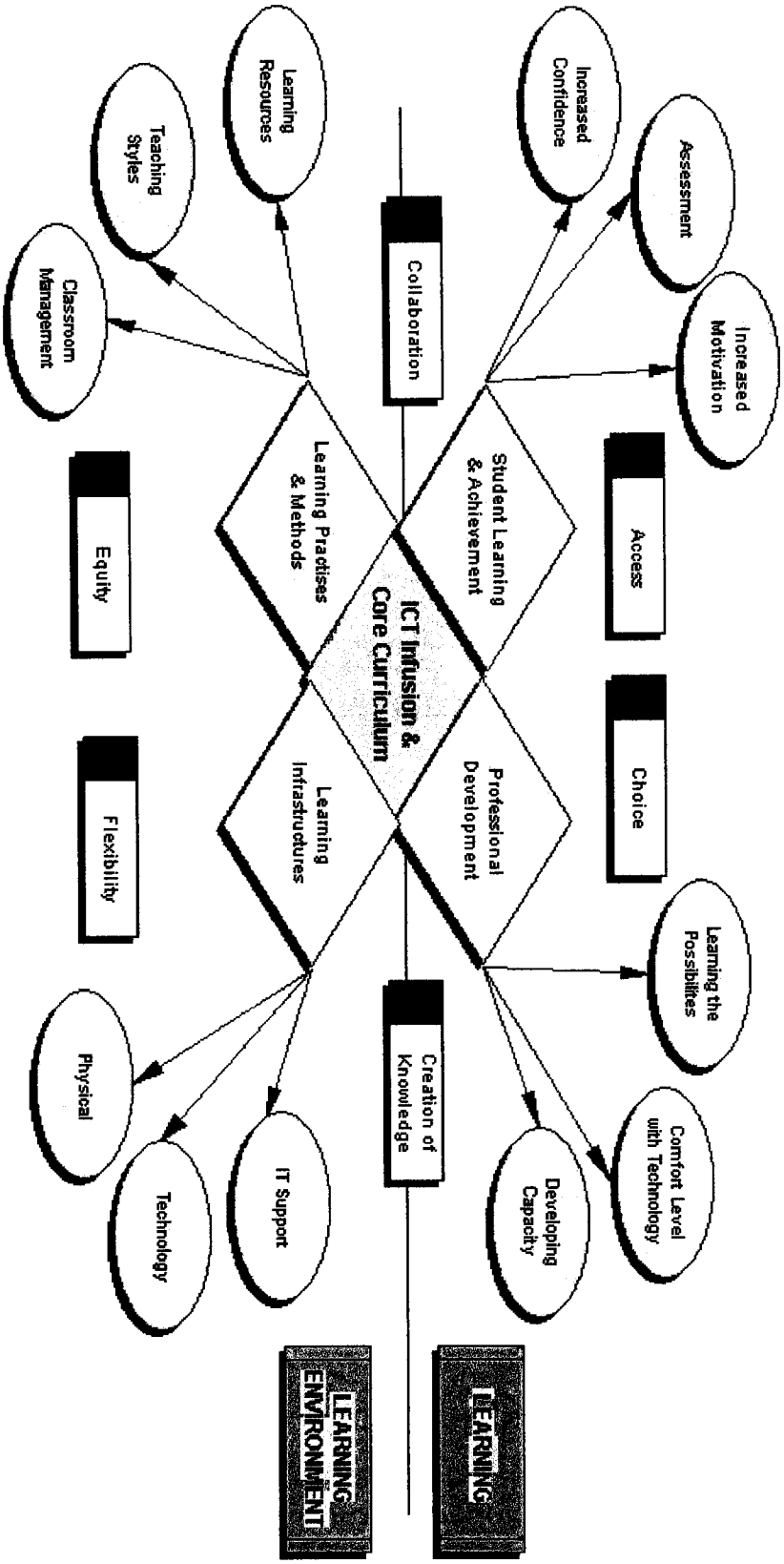

Figure 3. Data coding themes.

Learning Environment

The type of supports and structures that are created for learning environments play a significant role in determining the quality of learning opportunities available for students. Excellence in teaching and learning is facilitated when teachers have a solid foundation of best practices in learning and teaching methods. The physical and technology infrastructures also play key roles in enabling teachers and students to interact with and extend the flexibility of the learning environment to meet the individual needs of students. Over 75% of participants in the study discussed how these technologies provided an opportunity to pursue good pedagogical methods because of the flexibility of the technology infrastructure. It is a chicken and egg scenario, where it can be difficult to implement good teaching practices and methods without good infrastructure to support the teaching practices and methods, but teachers also need quality practices and methods established to take advantage of the infrastructure. In the following sections, comments from teachers and students, as well as observations of the researcher will be examined to determine the benefits of wireless LAN and portable digital devices in the learning environment.

Learning Practices & Methods

Tools and resources within the environment allow you to apply different teaching practices that will engage learners intellectually, socially, emotionally, and physically in a purposeful discovery of the curriculum content. The introduction of a new technology or system needs to empower teachers to maximize best practices and create new methods to help students to accomplish the learning outcomes. When technology is brought into a

classroom, its use needs to be driven by how students learn, not by constraints imposed by the technology.

Learning resources.

To provide a full and varied learning experience for students, teachers and administration strive to have a number of different resources available in the school. These resources can range from stationery supplies, to books in the library, to videos, to name a few. The wireless LAN, wireless devices (such as laptops, color printer, color scanner) and the applications on the laptops are another resource that teachers can use in their instruction, and students can use to enhance their learning. Just like any other resource, the laptops are not meant to be used at all times during the day, and are not always the appropriate tool for a task, but simply offer both the teacher and the student another choice. Of the teachers interviewed, 81% found that the wireless lab gave them greater choices of how to use this resource for instruction compared to the traditional computer lab and allowed them to look for more purposeful opportunities to use them within the teaching of curriculum concepts.

As T35 mentioned, "the computer supplies many of the tools the student needs on their own to complete a task." However, the computer is not always the best tool for the job. T10 noted that having the lab in the classroom helped students to learn how to "make decisions about when it is, and when it is not the most appropriate tool." Part of this learning process, according to T25, was allowing students the "flexibility to choose the best tool for the task, which also includes paper and pencils."

As students learned to include the wireless laptops as classroom resources, they learned to be more discerning about when to use the technology, and when to rely on other resources. One principal, A3, described it this way:

> ... I've got this really cool book that my buddy brought in on space or whatever we're doing and so it's got lots and lots of resources within text. So I don't have to go to the Internet in that case, because that is what a lot of those first, first projects were all about. Finding a website, cut and paste into your own work, and calling it your own. I mean, it was like giving every kid a photocopier and a library.

T6 noticed that the students learned to be "critical users." As A1 described, the portable lab "improved students' ability to work because they had greater choices to accomplish curricular goals." With the small footprint and flexibility of the wireless laptops, more computers could be available in one class than just two to five desktop computers. They could take the tool with them and use it in a variety of settings, giving an opportunity for more purposeful use of the technology. In the past, going to the lab was often a scheduled event in the learning instruction. It became more of a natural resource.

Having the laptops in a classroom also gave more choice to teachers. T2 wrote that "the lab proved to be an excellent tool to support our learning, rather than the object and purpose of our learning." Technology no longer needs to be included as a subject to be taught, but rather becomes just a resource to be used as a part of learning. T17 learned that "people can be working on the same topic but they can be working on it in different ways and just one of the ways is using the technology."

As teachers truly came to see that the technology was there to enhance their instructional environment rather than be something to teach to students for its own sake, they were able to use the technology more effectively. A3 observed this change:

> When I look at teachers using either a CD or Internet and having the projector and having it work in the classroom, that was much more used by teachers once the wireless was there, or having the video projector, and that made it much more possible for that to happen and teachers started to think about doing that and using that, so that it wasn't that every kid needed their own computer, and so that was, whether it was wireless or whether it wasn't, it was the fact that it could be used as an instructional tool.

Computers, like many other resources in a school, need to be shared among students. The mobile lab is no different. One problem with sharing resources is ensuring that all students who need to use a given resource have access to it, and that the access that they have is sufficient for a meaningful learning experience.

In many of the schools included in this study, access to computers is a challenge. Due to cost and support restrictions, there just are not enough computers to meet the demand within schools. The lab brought an increase in access to digital learning tools, which had nothing to do with the marvels of wireless and everything to do with just increasing the student to computer ratio for the two to three months that the lab was in the school. The laptops were able to help meet this demand, partly just because bringing the lab to a school meant more computers were available, but also because they were used in different ways. A2 described how the laptops helped to increase student access to technology:

> My greatest frustration was never being able to have available to the students and the staff the resources they needed. And, for that period of time we had resources that would allow them to do some of the outcomes that we . . . didn't have the ability to do.

A1 described it this way: "More computers in the school increased access time. All teachers increased the use of computers because they had more access time for them." A23 noted that it was "easier to plan work with computers because we had greater access."

Not only did the laptops allow for more access time, but they also allowed for access in places where a wired computer could not be used. A7 described the situation at his/her school, where they have classrooms that are portables. These rooms are not wired into the computer network, which meant that the only options for those students was to access a computer in the room that was not attached to the Internet or other school resources, or to go to the library. With the mobile lab the wireless extended the access to digital resources on the school network and the Internet to the portable classroom. These students and teachers now had access to these digital resources in their own room at anytime during the instructional period. The teacher now had greater options and choices of how to use these digital technologies ubiquitously because of the flexibility the wireless LAN and mobile laptops provided.

Teaching styles.

A limitation with traditional labs and how schools access technology is the lack of ease with which a teacher can change teaching styles or classroom setup to engage the

students with the curriculum through different learning processes. The laptops and access to a wireless network allowed for teachers to continue to take the styles that they use in teaching other subjects, and use them to teach with technology. It became more natural to implement this use of the ICT program of studies through core curriculum learning outcomes. This happened because the laptops could come right in to the classroom, where the teacher had already set up a learning environment designed to engage those students. Rather than having to spend instructional time going to the lab or adjust one's teaching style for a particular lesson to accommodate how the lab was set up to meet the needs of the whole school, the teacher can use the technology in the classroom, where there are visual queues on the wall, books and other resources that are needed to support the curriculum that is being covered.

In analysis of the data it was discovered that teachers were more open to using a variety of instructional strategies when using the digital resources of the wireless lab. One of the reasons for more openness to exploring alternative instructional practice when using digital technologies was that teachers felt more comfortable being in their own classroom instead of a lab. 43% of the teachers commented how they felt more comfortable allowing students to use the technology in inquiry and exploratory ways because it fit naturally into the learning environment of the classroom. T5 said, "I found that at first, it was important to let the students explore and try out the different skills that were being taught." T40 noticed that when students explore on their own, they are "able to solve far more problems than (we) realize." Many administrators also noticed, as A4 states, that teachers used the laptops in a "more exploratory way", letting students try things out, share, and teach each other.

As the teachers tried new ideas in their classrooms, they shared these ideas with other teachers in the school. This led teachers to "increase their confidence level to assist them with their own professional growth and ultimately with the teaching and learning in the classroom," as A25 said. T12 described the learning he/she experienced with the mobile lab.

> It has provided me with some new challenges and possibilities for teaching. I am forever coming across different ideas and projects – and never enough time to implement them. I really believe it has kept me from becoming stale. Being involved in projects and new directions for professions growth has been exciting and invigorating.

T9 commented how he/she was able to go from using the computers in a U shape structure, to a pod, and then to straight rows in a traditional style. What this allowed for was increasing teachers' confidence to take a "risk" and use the technology in their teaching practice and curriculum learning strategies with students. When they could see how easy it was for the computers to fit into how their class was designed, even the most reluctant teachers became interested in exploring how the capabilities of the computer could empower student learning.

Classroom management.

An important theme that grew from the analysis of the data was how classroom management strategies, procedures and interactions between teacher / student and student / student were impacted. It was observed through classroom observations and comments by teachers that the wireless lab required different management strategies, provided

greater flexibility as to when, how and why a student might use a laptop and impacted the opportunity to react socially between the class and instructor. In the ideal environment, teachers need to be able to observe students, and the work they are engaged in, easily. It is helpful to have visual as well as oral communication occurring. The ability to move easily throughout the learning area and interact with students is a critical component for establishing rapport with students, helping students and focusing students on their task. The wireless LAN and portable laptops created an opportunity to work more closely with students while leveraging the flexibility for students to access the learning tools in a variety of settings and situations.

Supervision - The most obvious change was that classes now had access to many computers in the classroom and, in the case of Strathcona-Tweedsmuir, one to one access to a computer in the class. Students and teachers had a choice of using the mobile lab in conjunction with the traditional setup of the school's computer lab or classroom computers. Traditionally, using the computers either meant splitting up the class, to send some students to the library to use computers while the remainder stayed in the classroom and worked on something else, or the whole class going to the lab, and all working on the same thing, sharing computers. With the lab, teachers were able to bring the computers to where the students were, and eliminate the need for extra supervision. A1 described the benefits this way: "The ability to supervise students was greatly improved because you could bring the equipment to the students, rather than send students to the equipment. For example, we have to send students unsupervised to the library." A2 described the same problem, having to somehow supervise students in two locations at the same time in the traditional setting, and the welcome change of being able to supervise students using

computers and those not using them all in the same location. He/she summarized by saying "it just made everybody's life so much easier in terms of using technology."

However teachers did not always keep their class together in one location. For example, one class was doing experiments in the hallway and using the laptops to collect their data entry. This required the teacher to not always see the students. However it was easy to move from class to hallway to monitor the work of the students.

Movement - The physical setup in many labs compared to the setup in the classrooms is very different as well. Many teachers spoke of how their classroom management techniques had to change in the lab, because it was set up differently than the classroom. Due to wiring concerns, many of the labs are set up in rows, and are awkward for teachers to easily move around and assist students. A3 described the difference between the two settings:

> You know, that's interesting, because the computer lab is not that much bigger. It's the same size as a classroom, but … it's the way they have it set up, maybe that's something to think about, because you have to go down the aisles, and back, and if you're down here it's a long way round to get to that person there. But with the wireless you don't have to worry about how everything is plugged in so it doesn't all have to go down this row. So you can jump, you don't have to be taking the long routes around to get to kids.

T31 also described the difference between the lab and the classroom and the impact:

> One of the troubles we have in large classrooms is it's not always easy to get to every child. And, it's particularly not easy to get to every child in a large class, which is set up in this computer lab configuration where we have to run down

these aisles. And, it did make a difference. It made a difference to the impact we felt we were having.

The laptops themselves also offered an opportunity to change classroom management, due to their small size. The smaller size made it easier for the students to participate. T14 described the impact of this smaller size as follows:

> Because the laptops were small, you could see what was happening over them, the kids could see what was happening over them, the kids didn't have to peer around to see what was going on, they were well aware of what was going on in the rest of the classroom, and it was just so much easier than in a very spread out lab situation. The size [of the laptops] also made it easier for the teachers.
>
> They still had a sense of what was going on in the classroom because you could see over them. It was easier for the teacher and the technician to get around and see what everyone was doing. There was a big efficiency there, and it was a huge issue in terms of the supervision. It was so much quicker to take in what everybody's doing.

The comments by teachers can also be supported by observing some photographs taken in the classroom. In Figures 4 and 5, the impact that the design of a lab can have on classroom management can be seen. First, the design of these labs affects the ability of the teacher to see the students' faces and have eye contact. Many labs have power drops that impact line of sight for students and teachers and force classroom designs that must be fixed and cannot easily be moved to take advantage of other forms of instruction or supervision. To compensate, some schools have moved away from power drops to running computer power along the walls. This creates a situation where students' backs

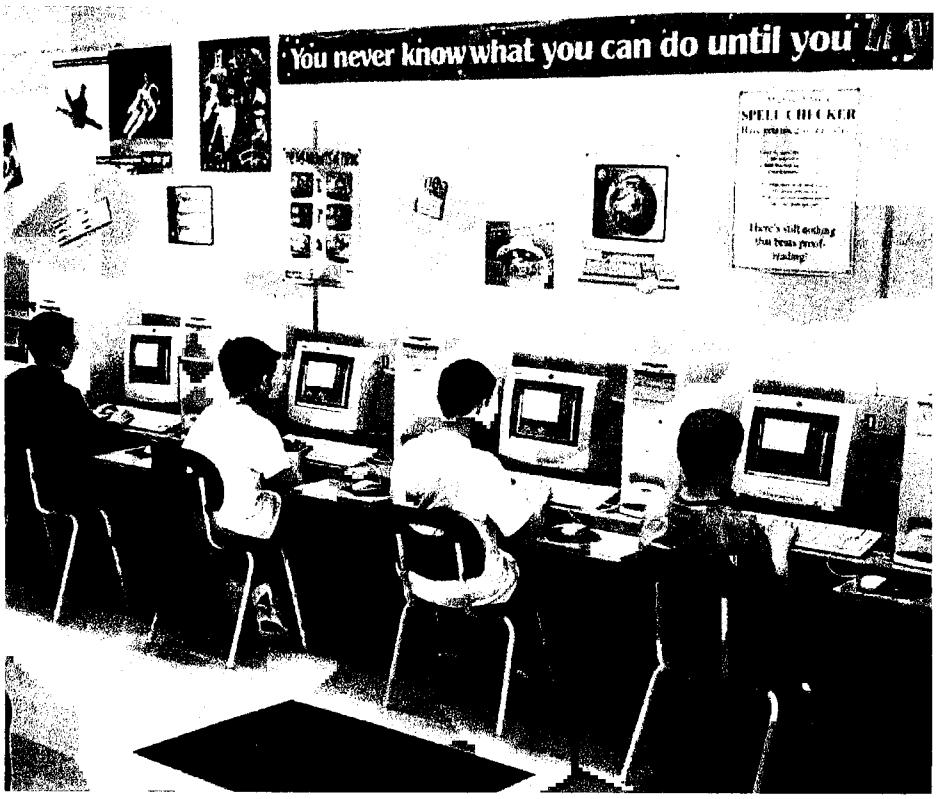

Figure 4. Students facing bulletin board while using computers.

Figure 5. Teachers helping students at computers facing wall.

are towards the teacher and the center of the room and the students are generally looking into a wall, whiteboard or bulletin board. The students' backs are always to the instructor and the teacher has to approach the student from the back or side.

Another observation was that the size of the desktop computers impacts students' participation in hearing, seeing the teacher and following lesson instructions. The following excerpt from the researcher's notes illustrates the difficulty the size of desktop computers can cause:

> I went into the desktop lab to work with some grade 1 students. Initially, I only thought that 16 of the students were present and then when I moved to the front of the lab I noticed the other students behind their desktops. I was unable to see them unless I moved because the size of the desktops in relation to the size of the students' bodies.

Figure 6 demonstrates the size of the desktop computer. It takes up a large amount of working space and is half the size of the girl. Her eye level is below the top of the monitor. In Figure 7 it can be seen that even though the lab was set up to help facilitate collaboration, most elementary students could not be seen from the other side of the computer if they were sitting down. This was reaffirmed by teachers, especially after they were able to compare the functionality of the laptops to the desktops. T9 stated that, "the size of desktop computers made it hard to see students." S12 commented that, "the computers in our lab are almost as big as me. I like the I-book because it is small and I can get close to it. It also fits on the desk and I used it on the floor during reading time". It was also noted during classroom observations that the desktops were seen as more intimidating to students than the laptops.

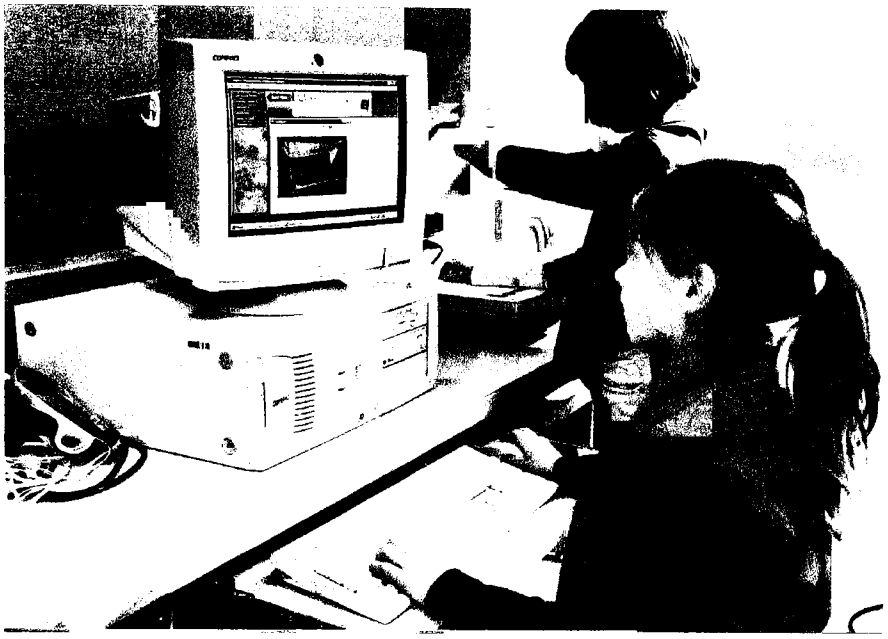

Figure 6. Student using large computer.

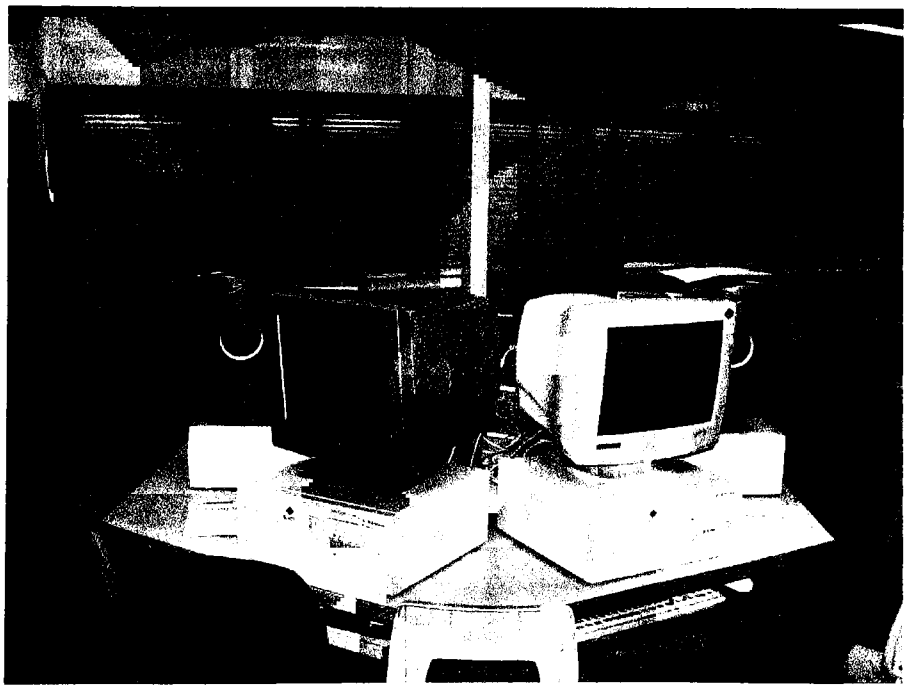

Figure 7. Computer lab with desktop computers arranged in pods.

With the laptops, teachers could easily see the students' faces, observe what they were doing and no power drops were needed, so line of sight between teacher / students and students / students was open in all directions. Figure 8 shows how easy it is for a teacher to approach a student using a laptop, and still be able to see other students. Figure 9 shows students using laptops in their classroom. They are able to sit in the same arrangement as they usually do, and still see the teacher and other areas of the classroom. They are able to see over the top of the laptops.

The changes in classroom management led to changes in student behavior. Many teachers had discussions about "appropriate behavior on the computer", as T27 said, including what Internet sites are appropriate and when to use email. This allowed students to take more ownership for their own learning, causing them to be more focused on the task at hand. Many teachers even gave students the responsibility of managing the equipment, keeping it organized and powered up. T2's comments summarize the impact this had on students:

> The students were so enthralled with the computers that little, if any behavioral adjustments needed to be made. The students were so focused and task-oriented that it allowed me to circulate and interact in a more facilitative role, rather than the disciplinarian.

During classroom observations, it was interesting to see how students did take greater ownership and responsibility for the laptops. When interviewing students it was observed in the language of students that they showed more ownership for the laptops over the traditional lab. When describing the computer labs they would use words like "the computer lab", "go down to the lab", "the computers in the library" or "the school's

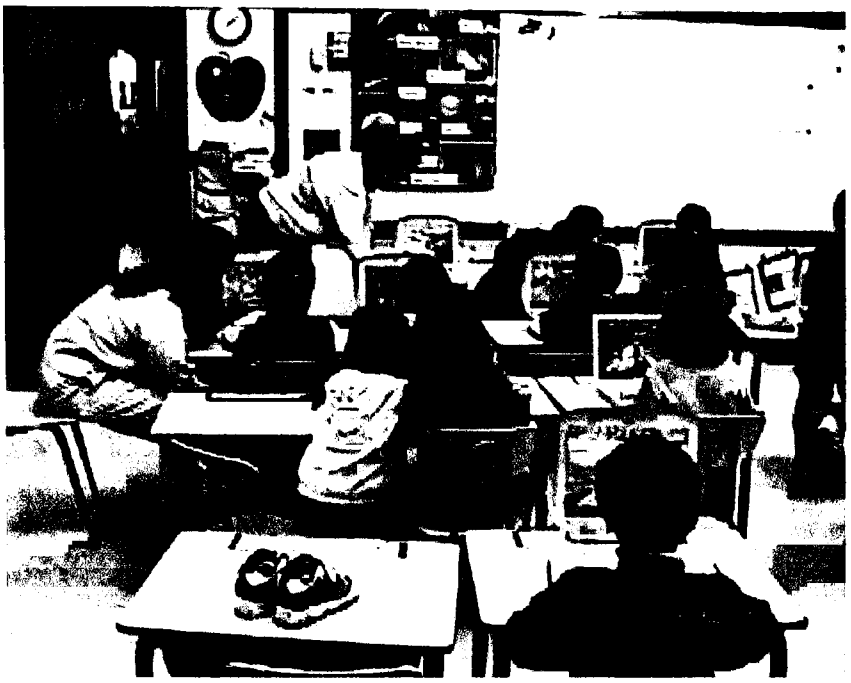

Figure 8. Teacher helping a student using a laptop.

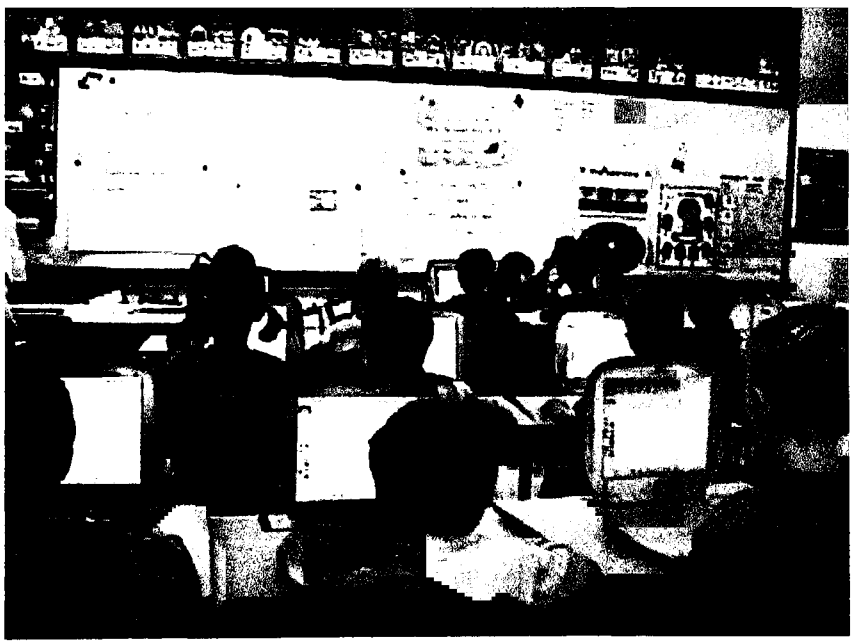

Figure 9. Laptop use in a classroom.

computers". When they shared comments about the mobile wireless lab the words were "my laptop" and "our class' time to use our iBooks". This was more evident with the division one students who saw the classroom as their main learning place. S22 said that "I like that the computer fits on my desk, where my pencil crayons and lunch is". Another student, S7, said, "it feels like it is mine and I want to take care of it because it is in my territory". An inference can be made that students felt greater ownership for objects, property or learning resources in their classroom than they do in the rest of the school. Throughout the use of the lab, the computers have not received any purposeful damage by students, while this did happen to the desktop computers. In the past two and a half years, the only damage occurred when a teacher pulled the CD cover off a computer and a computer being accidentally dropped when it was being carried.

Learning Infrastructures

There is a parable in the Bible about a wise man and a foolish man. They both built houses on different foundations. The wise man chose to build his house on a rock, and the foolish man built his house on sand. When winds and rain came, the foolish man's house was destroyed, because it was on an unstable foundation.

The infrastructure is the foundation in the learning environment. It is the responsibility of educational leaders to choose a wise foundation. Often, the focus is on the pedagogical foundations, but the physical foundations need to be considered as well. The physical structure of the school and classrooms, the design of the technology in the school, and the actual technology itself impact the instructional choices teachers have, and the way people collaborate and make connections when learning or developing

relationships. The physical design also determines how students can be engaged in the content of the curriculum and how they can move around in the classroom or school.

Physical space.

Bringing the mobile lab into a school complemented the physical infrastructure of the school, and expanded the reach and access of the technology learning tools within that physical infrastructure. Every time the wireless mobile lab moved from one room in the school to another or from one school to another there was sufficient flexibility in setting up the technology to mesh naturally with the design of the classroom or school. Appendix D – Blueprints of School Layouts shows the layout of school building infrastructures. Each building was unique and the technology was required to move from school to school and room to room within the buildings.

While the buildings were all different, and many would have caused problems for wiring, the lab was very adaptable. It could be moved and set up in less than a day. No new furniture, extra wiring, hubs, or switch equipment were needed.

Some of the physical buildings did have limitations. For example, Glenbrook, Killarney, and Hillhurst all have different levels, causing problems when trying to move the lab up and down stairs. This was usually overcome by scheduling, so that the lab would stay on a given floor for a week. The only other limitation was at Hillhurst. Due to the sandstone walls, which caused interference, the access point had to be moved more frequently.

Aside from these limitations, the lab was able to adjust to how classrooms were already set up. For example, at University Elementary, each room is an open area and

was designed for classroom observation by practicum students at the University of Calgary in the 1960s and 1970s. When desktop computers went into this school, limitations and constraints of wiring removed the use of some classroom space and altered teaching activities. In Figure 10, the computers are along the whiteboard and in some cases required specialized desks to be purchased. This design had to occur because of the unique walls that can be opened or closed and the v structure of the class. The only place to put the desktops was along the walls, to access power and cabling. Drop poles were of no use because of the extremely high ceilings.

Figure 11 shows how the lab was able to sit on existing tables and be used anywhere in the room without having to block whiteboards or restrict utilization of the physical space. In addition, all 22 of the laptops that were part of the lab in the classroom could easily fit. With the desktops, a class was limited to four to six computers in the room because of the physical space they absorb. In one of the schools, when they first received some desktop computers they spent large amounts of money removing the coatrooms which the students used. The coatrooms were taken out of the class so that four desktop computers, the furniture and wiring could be fixed along the walls. The wireless and the laptops allowed access to the Internet and server applications anywhere in the room and not just along the wall. The flexibility of wireless and laptops allows greater space utilization with no need to remove coatrooms or build new furniture.

As noted before, one benefit to the mobile lab is that it can be used in the existing space in the school, without any changes. Desktop computers have additional costs associated with them, because of changes that need to be made for wiring and to fit them into existing space. A5 noted that laptops "don't have to be figured into space, where

Figure 10. Desktop computers along whiteboard.

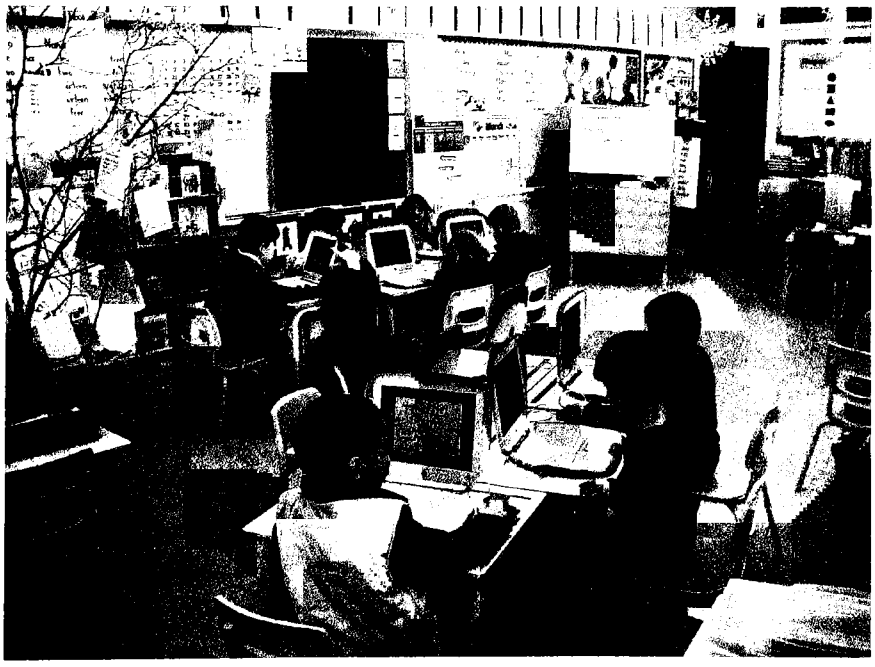

Figure 11. Laptops being used on existing furniture.

certainly desktops do have to be figured into space." T32 also commented that there was "no furniture required, students used the computers where they were learning," and T8 said that the laptops "were adapted to the existing space and furniture."

The mobile lab was also more flexible than a traditional wired computer lab. T2 noted that the lab "allowed for more flexible groupings (of students) and a more relaxed, natural learning environment." A7 described the flexibility this way: "the lab would adapt to them. If they were already in groups in classrooms, then they used that space, if not, then they would just move out of their rows and just sit wherever they needed or wanted." He/she also mentioned that different teachers were able to use the lab differently in their classrooms, to adapt it to the particular layout of that room. This is demonstrated by Figure 12.

The mobility that wireless laptops bring to the learning environment can best be summed up by the reaction of T2: "What freedom!" The mobile lab gave teachers the ability to use computers in different locations within the school; they were no longer restricted to the school computer lab. The following comment from A5 shows the impact that the mobility of the lab had on his/her perception of wireless technology.

> I think there was a very obvious difference was that the transportability, it made it … seem like a tool, probably more than ever, because kids could simply pick it up and walk to any location in the school to do some of their work individually or in groups. So the amount of flexibility it afforded was probably the #1 support to student learning that I saw and I didn't expect that I would observe that, I hadn't really prethought it, I think that made me almost a big supporter instantly. …It's sort of like taking a pencil, you don't want that pencil chained to your desk, and

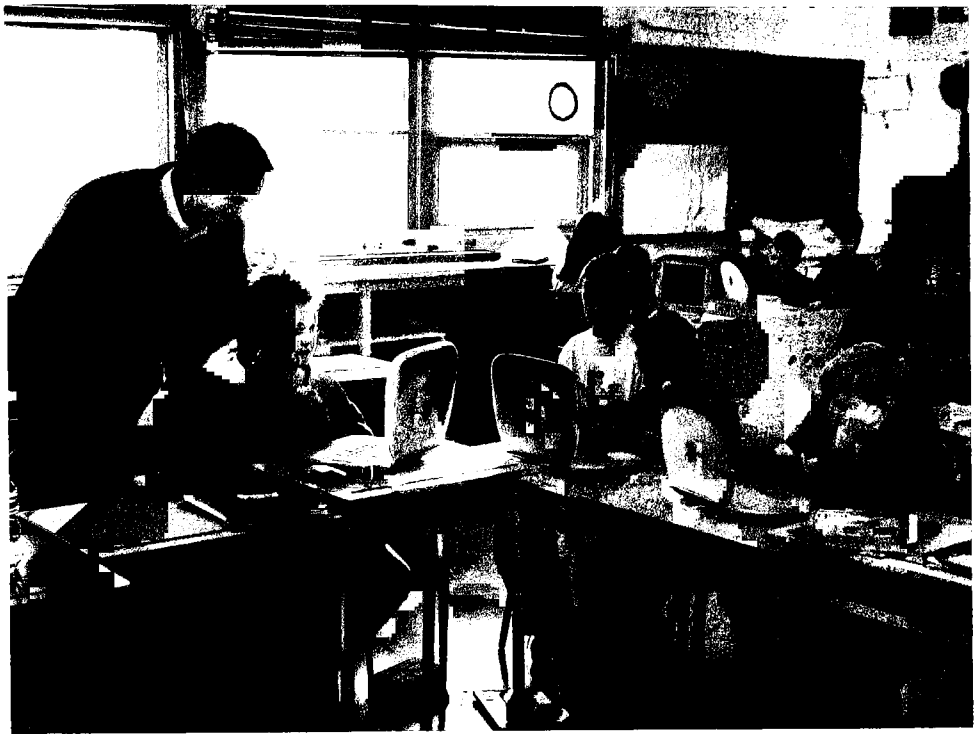

Figure 12. Laptops used in existing classroom configuration.

other kinds of communicating … shouldn't have to be so location specific.

And, many students did take the laptops to different locations. During observations at the schools it was common to find students using the laptops in the halls to conduct science experiments or complete work. In Figure 13, two students have found a quiet and comfortable place to work on their project, on some chairs in the hallway. They were able to access the school's servers and the Internet through the wireless LAN.

These observations are confirmed by comments of teachers who participated in this research study. As T2 said,

> Both my students and myself loved how they were able to work anywhere in the school on the computers, rather than being confined to the computer lab. I was surprised by the locations some groups chose to work in. For example, some chose to remain at the desks while others chose the hallway, floor, tables, Library, etc.

Another effect from the mobility of the laptops was that it allowed a change in how work was completed in the classroom. Because the laptops were small and easily portable, students could pick them up and move around the room to share their work with other students or the teacher. T8 noted that they could also move the laptops in order to work "at their own individual space without having to travel to a different location such as the library." When a class was involved in group work, each group could move to a different location, and be more spread out than they could with the wired desktop computers, as Figure 14 demonstrates.

Figure 13. Students using a laptop in the hallway.

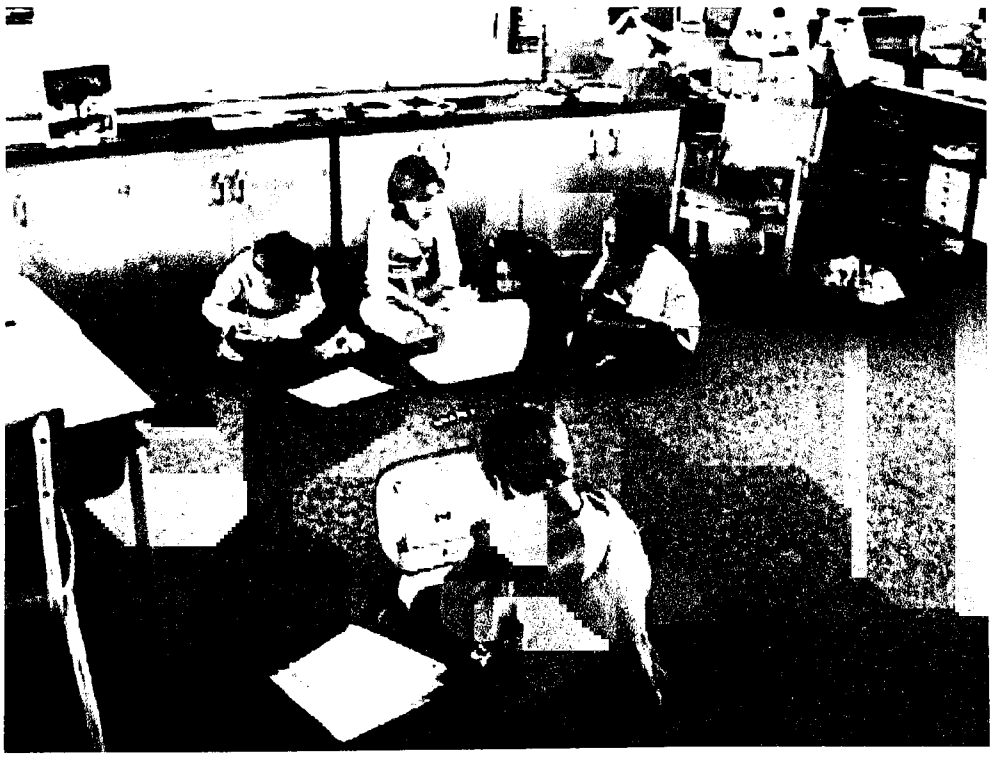

Figure 14. Groups of students using laptops on the floor.

Technology.

One negative impact on classroom management was teachers wondering when the batteries would run out. No power was needed for the morning classes as long as the teachers plugged in the computers the night before, a classroom management strategy that teachers needed to apply. With the desktop computers there was no need for worrying when or if power would run out or plugging them in to be recharged. The laptops had to be plugged in over lunch. When battery power ran out during a class, power cords and power bars were strewn across the class to keep continuous access to the applications going. Strathcona-Tweedsmuir had special power bars designed, which were about four feet in length, making it easier for students to access power for their laptops. Teachers had to be concerned with the power cords and power bars not becoming a tripping hazard and needed to remind students to be careful when moving around the classroom. This limited the movement of the laptops, but still allowed the benefits of accessing the school's server and the Internet. Despite the battery challenges, the laptops still allowed for a higher computer to student ratio than what a class was normally used to experiencing within the classroom.

The presence of a lab technician made this easier since he would help with power management with the lab. However, if the technician were away, teachers who felt less comfortable with technology would often not use the laptops, especially in the late morning, because they were worried about plugging them in. Companies who manufacture laptop batteries are now creating cost effective designs where battery power lasts for 6-9 hours, which will make this classroom management problem less of an issue. Other companies make paper-thin batteries that sit under a laptop which last for up to

eight hours and can be charged numerous amounts of times. In order to solve some of the problems, spare batteries were kept on hand.

IT support.

A big factor in the success of the mobile lab was the technical support that was supplied along with the computers. A full-time technician worked with the teachers using the lab, to both solve technical problems and provide on-the-spot training for teachers and students. This has been invaluable to the teachers and administrators involved with the lab. As A3 put it, "if the project had brought 30 laptops to the school, the same things wouldn't have happened … if they had just come, and you were supposed to use them, without a technician." Not only did the technician troubleshoot and solve technical problems that occurred, but also he helped those teachers who were not comfortable with technology with the setup and getting each class running smoothly when it was their turn for the lab. Then, he was available during the class time, to help with any questions about the software programs from teachers or students. T39 described his help as "a collaboration between the technician, the teacher, the student."

More than having someone around to solve technical problems, though, the technician's understanding of the potential of the laptops for instructional use was valuable. A1 said that "having a technical assistant increased the teacher's willingness to try new programs and ideas. They did not feel alone if they ran into any technical questions." T20 explained that the technician was able to take moments through the day with teachers, to "give them a new idea or teach them a new little bit of something and do that on an ongoing basis for six weeks." A4 described various levels of support this way:

> Mechanical support is the guy who gets it unstuck, or connects up the bits and pieces or loads software and says, 'OK, it's done.' Whereas technological support is support that helps you with understanding the technology as well as making the machine run.

The technicians with the lab were able to supply "technological support", and during the hiring processes they were selected not necessarily because of their technical expertise, but because of their interpersonal skills and the ability to work with people including students. S23 said, "what I liked most about the lab was (name of technician), he helped me a lot".

Throughout this analysis, it has become clear that technology support is a key foundation that is necessary for the infrastructure to provide the opportunity for teachers and students to engage in the use of technology in thoughtful and purposeful ways. The lab would probably have been less successful if it had not been for the technical support. Wireless and laptops are not fully at a point of total user friendliness. The technology worked well when it was set up and molded into existing school infrastructures. The wireless LAN and laptops provided more flexibility for the learning environment when they were supported. The same is true for desktops and labs, there needs to be ongoing support to keep the infrastructure solid and reliable so that it is available when a teaching moment or learning opportunity occurs.

Learning

Professional Development

Bringing a mobile lab into a school and changing the learning environment is not enough to change student learning. Methods of instruction must be transformed as well,

through professional development of teachers. This was acknowledged during the planning of the mobile lab project, and formal professional development sessions were set up with each school that received the lab. Generally, a one or two day professional development session, with sub time for teachers, was available to each of the schools. While some positive feedback was received about these days, such as A1's comment that "one professional development day to 'plan ahead' made infusing technology to upcoming curricular goals much easier", and T6's comment that "the teachers did benefit from the PD and infusion of technology in the building", the informal professional development experiences seem to have been more effective. One explanation for teachers' reluctance to participate in formal PD sessions, provided by A3, follows:

> It's a tough thing to look at professional development because teachers now see it as an add-on, something else that they have to go and learn and they can't do it. If there's a way to do both within the classroom, that worked, but that's pretty much been taken away as an opportunity. I mean, even if you can provide them with time out of the classroom, they have to get ready for those subs and they see that as extra work even though the end result is better. I think that's what you're finding within ICT is that I can give you four sub days to be able to work through a plan, but that means they have to do the classroom stuff that is still their first responsibility.

Learning the possibilities.

The wireless lab provided an opportunity for teachers at each school to see the possibilities of what they could do with wireless laptops and the associated applications. The technology tools were most effectively used when a teacher employed students

through inquiry learning. The mobility of laptops created an opportunity for all teachers to participate because of the ease of fitting the technology infrastructure within their classrooms. Even during professional learning sessions during a professional development day at lunch or after school it was easy to move the lab into an ideal learning situation without too much hassle. In Figure 15, these teachers were using laptops that had been with students in classes just before lunch. 10 laptops were brought into the library and an instant wireless lab was established for this professional development activity. In Figure 16, another teacher sits comfortably in the staff room preparing a lesson on her laptop while being able to access the Internet and resources on the school server. T29 said "I love being able to plan and work anywhere in the school."

The informal training was very powerful. Much of the learning that teachers did was by trying things out on their own, "learning right along with the kids," as T34 put it. To further help teachers see the digital resources on a laptop as a tool they were encouraged to take the laptops home in the evenings, weekends or holidays. Approximately 39% of the teachers took the laptops home during the time the wireless lab was in their building. This allowed them to have more time to experiment with the software on their own and become comfortable with technology in the comfort of their homes. One teacher, T27, said that he/she enjoyed being able to take the same laptop and software home that the students would be using the next day. As the teachers became more familiar with the technology, they were able to be more efficient with it and began to see possible linkages to the curriculum. Once teachers began to use the lab with their classes, they were eager to share their experiences with others, and this is where the greatest learning occurred as the knowledge from these experiences added to the culture

Figure 15. Teachers using laptops.

Figure 16. Teacher planning lesson using laptop.

of the initiatives that were occurring in the building already. T12 said:

> It has provided me with some new challenges and possibilities for teaching. I am forever coming across different ideas and projects – and never enough time to implement them. I really believe it has kept me from becoming stale. Being involved in projects and new directions for professions growth has been exciting and invigorating.

Many people surveyed spoke of sharing between teachers, or between the technician and teachers. These conversations left teachers with a desire to improve a skill, or to try a new project that another class had done. There was even sharing done between teachers and students. T3 described a relationship that he/she had developed with a student that continued in to the next school year, where he/she was able to receive some computer training from the student. A transcript of his/her description of this relationship follows:

> T3: Teachers learn from students. We're doing a mind mapping project this year, and with the portable lab we learned how to use Inspiration software last year. Do you remember Justin? From my class, that was doing a find-your-own adventure, choose your own adventure story. Well, Justin and I email each other all the time, still we're in touch, and I was working on a project this year with my kids and I couldn't remember how to get those frownies, you know the buttons, like for Hyperstudio, so there I go, zzzzz, sat down, emailed Justin, within what, next morning, zip, up comes my email, and here's my answer, Justin's told me ok you just adopt and all the rest of it and what buttons to go to. Isn't that cool?
>
> Interviewer: That's neat that you still have that relationship, or that email allows you to keep that relationship.

T3: And I mean he sends me a lot of emails, I should have never given him my email address. A lot of the kids have my email address, but he's definitely the most prolific. But isn't that neat, you know, that I can turn to a kid to do it? Because I just couldn't remember how with all those buttons.

Comfort level with technology.

"From my experience, quality professional development takes teachers out of their comfort zone and empowers them to take a risk" (Spicer, 2002, Free to Take a Risk section, ¶ 1). Teachers need to feel secure and people need to be in an environment where they can be positively encouraged, take risks and feel valued for the professional knowledge and practices they have already acquired.

It is challenging, however, even in the best conditions, when technology is introduced into the teacher's learning experience. David Thornburg discusses that the generation of people born before the 1980 are "Digital Immigrants". "Our children are natives of the digital age, and we are the immigrants. Our accent colors everything we do, including our teaching" (Thornburg, 2003, p. 13). Since most teachers would fit into the category of digital immigrants, it is easy to see why only 18% to 22% of teachers agreed or strongly agreed that they were comfortable using technology.

Elementary students are growing up with digital cable, the Internet and digital graphical objects and see the recent development of technologies as a natural part of their landscape. Most of the teaching population, as digital immigrants, sees technology as something foreign, something they have to do as part of the job.

The more learning barriers during a professional development experience that can be removed, the more successful the learning will be. As technologies become more comfortable, flexible, accessible and useable, the digital accents will be less noticeable. Teachers will speak the same language as the students.

However, digital immigrants can learn. According to the AISI pre/post surveys of the portable lab in the 2002/2003 school year, there was a 42.8% increase in the comfort level of teachers using technology after the lab had been to the school. One of the reasons for this is similar to a previous student comment that the technology was not intimidating. A1 mentioned that in his/her school "teachers range from fairly competent to technologically terrified. And particularly for the technologically terrified, the laptops were way less scary than those big machines sitting on tables. They didn't worry about breaking them or wrecking them. They weren't scared."

Again, the support of ongoing professional development and a technician to support the infrastructure also gave teachers the confidence to move forward in their learning and acquire skills in using the digital resources available on the laptops. This helped to build some interdependence between teachers in the building.

In many ways, the mobile lab was really intended for the teachers' professional development more than the students' acquisition of ICT outcomes. Livingston School jurisdiction, during their wireless portable initiative, gave the technology first to the teachers. If change is to take place and the ICT program of studies is to be supported within the culture of the school, then every effort must first be made to help teachers feel comfortable. Once they are comfortable with the technology, then they are willing to use it with students. As A3 described, "as teachers become more familiar with it, they'll hit

their ability and efficiency that they already have using other forms of technology. … They can whip a video in and out pretty quickly if they need to."

When bringing the lab to a new school, it was important to first talk about the curriculum the teachers were covering with their students. The teachers discussed the outcomes of the activities and some of the learning challenges the classes and individual students would face when learning some concepts. Then, the teacher was asked to brainstorm with the team or ICT curriculum specialist how the digital resources could be used within the project. This brought a great purpose to using the tools to accomplish the task instead of just learning the tool. The teachers found greater relevance when they could connect the using and learning of digital resources to the curriculum they were covering. This also increased their comfort level because the teacher(s) formed a bridge between the world of technology and curriculum.

Developing capacity.

While the lab was in a school, the excitement for using technology seemed to increase. A3 described this excitement, "the project itself made teachers so much more aware of the exciting and interesting projects that they could have their kids do. There is a great deal of excitement to continue this kind of thing through this year." Not only was there excitement, but also since many teachers were using the lab, they frequently shared ideas. T8 said:

> It [having access to the lab] has opened up many new possibilities to us as we heard about what our colleagues did as well as what we did. We would be even more excited to accept if we were given another opportunity.

The excitement was not limited only to the teachers, as this excerpt from the researcher's notes describes, " I noticed the caretaker with one of the laptops exploring what he could do and checking his email."

One of the biggest challenges with the research initiative was maintaining the momentum of learning by the professionals in the building while the lab was there. One of the decisions that were made during the pilot of the lab was to have the lab go to schools with a Mac environment, rather than a PC environment, for the most part. The reasoning for this was to keep the lab environment as similar as possible to the school's existing environment. Then, the same software would be used on both the school computers and the portable lab. With similar platforms, skills learned while using the lab would be transferable to the school computers, and could be used in the future.

Teachers can easily become frustrated with the learning involved to feel comfortable using technology in the classroom. A7 described the difficulty, "they've had a computer specialist here in this building for a while, the other teachers have not learned or kept up [with technology]... It will always be a problem because you cannot keep up." Teachers need to feel like they are not on their own. A3 spoke about this, when asked about limitations of the lab:

> The limitations only come from the teachers not knowing what to do with them. ... We've told the teachers what it is they are supposed to do, but we haven't ensured that we get there. ... I think it's just incredibly important that we educate our teachers and help, and having someone there helping teachers as they actually work makes just so much sense.

While most schools will not have a technician or computer specialist available to help teachers, 60% of teachers answered that they felt comfortable helping other teachers with technology, and 95% of teachers answered that they felt comfortable asking for help from other staff members, around technology. Having a supportive environment in a school, where teachers help teachers, will help to continue the momentum. As teachers continue to improve their skills, they can mentor other teachers. "As mentors become a part of the culture of the school, formal and informal conversations of this sort become more common and ongoing, and a discourse community grows up around technology integration" (Swan et al., 2002, p. 174).

Student Learning & Achievement

The wireless portable lab was used in many different classrooms during this study. These classrooms were in a number of different schools, involved students from all elementary grades, and students with a variety of needs and abilities. Yet, one common theme amongst the administrators and teachers interviewed was the noticeable change that occurred in student learning styles.

Increased motivation.

Everyday learning seems to take on a new excitement when computers are introduced. As T35 put it,

> The world is at their fingertips. Learning takes on an entirely new look. Children are often so enamored with computers that they don't even realize they are learning. If computers are used to enhance learning, rather than to drive it, they are an incredibly powerful tool to have. Computers should be used only to do

> something they couldn't do without them, or to allow them to something differently and better.

Because the students are excited about the technology, T18 believes that they "learn and accomplish a great deal within a short period of time. They are focused and engaged in their learning." This new focus on learning led to a modification of other student behaviors as well, as T2 describes:

> Little to no time was spent correcting inappropriate behaviors. The students were focused and task-oriented at all times. They couldn't wait to get started and never wanted to stop when our time with the lab was finished for the day. We became far more efficient and time-effective due to the short duration of our time spent with the lab daily, and because the students wanted to fit as much into their time with the lab as possible.

The increased focus on technology was not always positive, however. T4 describes that occasionally, students "lost focus on the task at hand" and were distracted by the many options available in the software they were using, or, as T3 puts it, were "distracted by other interesting web sites instead of focusing on their own topic."

Increased confidence.

Students were also able to take ownership for their learning. T15 describes that they "felt it was a privilege having the laptops in the classroom." This led them to "display incredible levels of teamwork and maturity while using the lab." A6 mentioned how they had had a problem in the past with students removing balls from the computer mice. However, once the administration spoke with the students, and let them know the

expectations they had for the students' behavior around technology, they did not have a similar problem occur when the mobile lab was in the school.

As students worked with the lab, with the support of teachers and the technician, they gained new skills. There were many students who excelled at the projects produced using the wireless technology, who had not had a lot of academic success up to that point. A1 said that these students were able to receive "increased positive feedback." As well, they were able to help other students. T12 described the change she saw in her students:

> I have had weak students that were usually unable to help others with academic work, but have developed an affinity for the computer. They then develop self-confidence as they help others with computer problems – sometimes even the teacher.

The group work involved in many of the projects also helped some students learn new skills and gain confidence, as described by A2:

> I saw … unexpected combinations of kids working together. I think it brought out in a number of children … who just can't operate with the confines of what you'd call a regular classroom, but they just starred when they got the technology, and they became leaders. …And some of the children who were fairly independent workers didn't necessarily have the computer skills so they had to rely on maybe Peter in the corner who was kind of a rascal in the classroom yet with the technical abilities. I think it gave some leadership opportunities for some children.

One of the great advantages to having the mobile lab in a school is the equity it can bring within a school. Many stories were told during this study, demonstrating students with many different needs using the computers. A3 summarized, "I feel having

the laptops at our school was a great success. Children of all diverse needs have benefited in learning the different programs. They felt proud of their end products."

Here are some of the moments that teachers and administrators shared:

- I think the usage of different software and adjusting it to the diverse needs of learners improved. We found with some of our kids with special needs, there was increased usage, increased production. (T36)
- I have 2 hearing impaired students that use it every day we use the computer to access information for research. (T1)
- For students who have challenges with printing/writing skills, the wireless provides a convenient option for written work. (T7)
- It's one more vehicle for kids to communicate with and to write, and they use it more readily. And for some kids for kids who would say need occupational therapy support, fine motor skill support, it readily, as other computers do, readily supports them, their products look as good as other kids products, so self esteem and things like that get enhanced. (A5)
- I use it everyday for my ESL student. (T1)
- My gifted students use the computer for a variety of learning opportunities. (T26)
- I think all the kids benefited. But the one I really was struck by was the computers with the special ed kids. And how quickly they were able to use the program, produce products. And of all the products that were put up on display, those ones caused the most comment from visitors, because we had them right by the front door, and they admired them and talked about

them, and then you'd say these were the children in the skill and prep class and then that was even more amazing. So I think there was some proof of the range of abilities that you could use them with. (A2)

- (There) are kids that don't have a lot of rewards for their thinking, because their thinking tends to be all oral. All of their responses are, and in schools we don't give a lot of … appreciation or reward for oral work … and these kids can think really well. But, it's that process of going to the papers, it just loses it, so to me I like the computers, they're more individually sensitive. (T3)

Students with special needs often have to have a special setup or move to the walls where a computer is in order to access technology that gives them access to the curriculum. The flexibility of the lab allowed a computer to be brought to a student who had special needs where they could still be part of the learning group and not be isolated from the other children.

With the introduction of the portable lab into the learning environment, learning could become more individualized. Individualized learning can be described as learning where "each student … works at his/her individual pace but also chooses (usually with the instructor's help) a specific goal and individualized assignments" (Kupsh, n.d., p. 3). The advantages to individualized learning are that it: "increases responsibility, allows for special needs, enables flexible scheduling, enforces constant quality."

As T1 described, when a class first started to work with the laptops, "each student was on a different point on the skills continuum when working with computers." Because of the variation in skill levels, the same instruction could not be used for all of

the students. Some children needed to learn basics about the computers and how to use various programs, while others were ready to start in on a given project. Not only did children start with different skills, but also due to the number of different programs available on the computers, T2 described that students were able "to increase their proficiency levels on several programs, and with the machine itself." Teachers were no longer forced to have the whole class work on the same program, or even complete a project to the same level of detail. T12 explained her approach to handling the different skill levels and different software available this way: "My teaching partner and I took an existing project on biographies which was very much student driven and made a website from which the students could complete independent studies at their own pace."

The ability to more easily offer individualized learning was appreciated by teachers. A3 commented that "we're always looking for opportunities to have more individualized instruction, and to be able to meet every kid's needs." T1 noted that as a result of working with the mobile lab, and "with the on site support, parent volunteers, and teacher, and peer sharing actively involved, the students' individual learning needs were met."

Assessment.

Increased access to technology leads to increased awareness of what can be done with that technology. This was true for the students using the mobile lab. They were able to go from using computers simply as a tool to accomplish a task, to assessing the end product. Because the students had more access to computers in the appropriate place and time, they began to understand some of the potential that the laptops offer. For example,

A4 described a group of students evaluating online presentations that had been produced by the class. They were able to discuss "why this one (was) more effective than this one that the other group (had) done, and the kids started to be more critical about how things were done rather than just looking at what was done."

With more exposure to computers, students are also able to gain an understanding of when it is appropriate to use the computer and the Internet, and when a different resource would be a better choice. One teacher described taking a group of students to the library to do research. With the school lab, all of the students would automatically go to the computers, even if they were just looking up facts that would be quicker to get from a book or encyclopedia. With the laptops, the students began to see the computer as just another resource, and, as T21 said, "started to learn when it's appropriate and when it isn't."

The students also gained a better awareness of the skills they actually had. When students were asked how much they knew about computers and what their comfort level was, they tended to rate themselves very high. This same phenomenon was observed with teachers. They seemed to equate, as did the students, that high computer competency was a result of one's ability to use the Internet, word processing applications or access games. Often the reason some teachers went to the lab with students was to do searching on the Internet. With the mobile lab there was an increase in the variety of applications used besides the Internet. The lab helped students assess their actual knowledge of what they did know and gave them opportunities to discover that there is more to computers than just games and the Internet. This was demonstrated by the variety of projects that students throughout the schools created.

ICT Infusion & Core Curriculum

How did having access to the laptops improve your ability to integrate the ICT outcomes into the core curriculum? T12 answered this way: "It is integrated with ease! Almost all of the outcomes are integrated automatically." This sentiment was echoed over and over throughout the surveys and interviews.

A1 said that big advantage to using wireless laptops is that they are "easier to infuse at the moment needed." As T25 described it, "even if you could only access a few mobile computers, you could use a 'teaching moment' right in the classroom." There was no longer a delay needed between a moment when technology could be used and when the technology was available.

The comfort level that the teachers developed with the technology caused them to be more effective with integrating the ICT outcomes as well. T2 wrote:

> It is amazing how many outcomes you can cover without even trying! The computers were a tool inserted into the unit plan, rather than the unit's central focus. By using the computers to accomplish unit goals, ICT outcomes were covered. The computers are merely a tool to enhance learning that is already taking place in the classroom. By using them in such a fashion, curricular goals across all subject areas will be met.

The increased access to technology that the lab provided also increased the ICT curriculum infusion. A1 commented: "Our teachers have many ICT outcomes ideas that they cannot implement due to limited computer access. The mobility of the lab and the

mere increase of access at least doubled their 'outcome' ideas to enhance core curriculum." A5 described the increased ICT infusion this way:

> Having access to the laptops, it helped the teachers hugely to integrate the ICT outcomes. Because it became less of an add-on and was just another thing that you could use in the classroom, and because they tried things out without being sure they were going to work or not, it didn't seem to need to be as perfect. And so they tried a way wider range of things than they'd been doing previously.

The teachers involved in the project also perceived an increase in the integration of ICT outcomes. Before using the lab, 40% of teachers strongly agreed that the wireless lab would facilitate the integration of ICT. After using the lab, 67% of teachers strongly agreed, and there were no teachers who disagreed or strongly disagreed, as can be seen in Figure 17.

Another indication of effective ICT infusion is the ability of teachers to assess how students are accomplishing the ICT outcomes. As Figure 18 shows, through the use of the lab, teachers' comfort in assessing these outcomes increased. Before the lab, only 43% of teachers felt comfortable with the assessments. After using the lab, 80% felt comfortable.

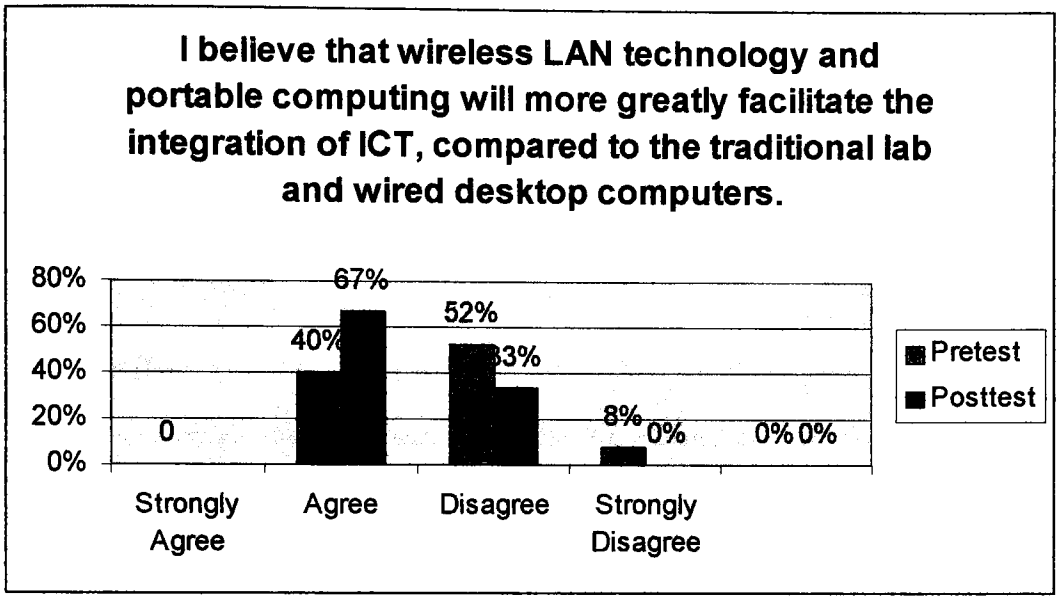

Figure 17. Survey – will the wireless lab facilitate ICT integration?

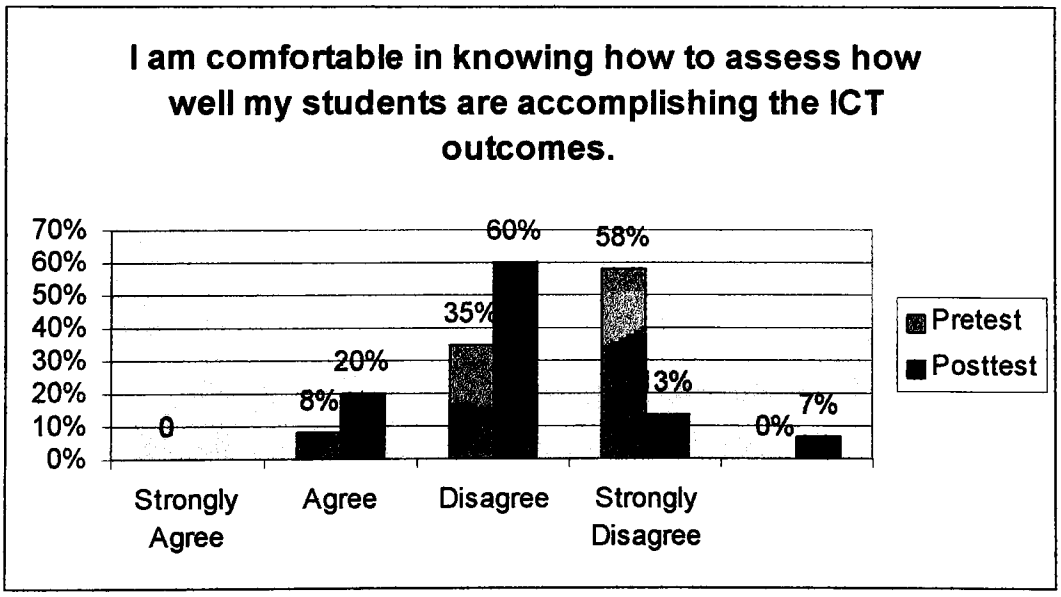

Figure 18. Survey – teacher comfort assessing ICT outcomes.

Conclusion

The purpose of this qualitative case study was to determine if the use of mobile wireless computer devices benefited the learning environments of elementary schools. It was also to determine if the wireless devices helped to facilitate more purposeful opportunities for students and teachers to truly implement the ICT program of studies into all curriculum areas. The wireless LAN along with the laptops of this research study did provide a greater potential over the labs and desktop environment to benefit the learning environment and facilitate more purposeful opportunities to implement the ICT program of studies and use technology in more meaningful ways in the curriculum. However, these powerful technologies are only resources and cannot by themselves change the course or direction of how students learn or facilitate on their own the implementation of a new curriculum.

Schools that participated in the study found the benefits of having the lab to be:

- Technology could be used many places throughout the school, not just in a lab setting.
- The flexibility and foot print size of the technology created greater access and equity of learning opportunity for the students and the schools who use wireless LAN and laptops.
- Students could use technology where they wanted to learn.
- Students were able to take more ownership of their learning.
- ICT integration was increased.
- Students enjoyed the smaller size of laptops compared to desktop computers.

- Ongoing support from a technician increased teachers' comfort with technology and their willingness to take risks, and to include technology in their teaching.
- With the wireless laptops, teaching styles did not have to be altered to fit the technology.
- Classroom routines did not have to be altered significantly when using laptops like they did when using the computer lab.
- Special needs students greatly benefited from the use of the portable lab.
- The wireless lab could be used with the existing school infrastructure. Changes in furniture, wiring, or space were not required.

Looking at the impact wireless technology and laptops has on school infrastructures has been a key part of this study. The study helped bring to the forefront the importance of having technology that works seamlessly throughout places where students learn. Wireless technology, coupled with the portability and size of laptops, created more opportunities and flexibility within the classroom and school for using technology in the learning process. The laptops were able to be used in all of the schools included in the study, despite the differences in school building designs and classroom layouts.

The challenges that were encountered during the project were:

- The batteries – they need to be charged more frequently as they age, and can cause problems for a class if they are not charged.

- Durability of hardware – as the laptops aged, power cables needed to be replaced and some touch pads became unusable. The laptops have a short life compared to desktops.
- Building design – some buildings had more than one floor, causing difficulties when moving the lab up and down floors.

While many benefits were noted, it is important to also remember that this project involved a portable lab of laptops moving into a school for a short period of time. Some of the benefits may be attributable to the novelty of the lab, and the excitement children experience with any change in their classroom. One administrator, A1, discussed the novelty effect of the lab. He/she noticed that the novelty generated a lot of excitement, but that once the novelty wore off, students and teachers continued to use the lab, and integrated the technology into their classroom work.

In addition, teachers and administrators received extra professional development and IT support as a result of having the lab in the school. Before the lab would arrive at a school, professional development sessions were held with the school to work with teachers on lesson development that involved technology tools. This contributed toward maximizing the use of the technology during class time and allowed teachers to experiment. Teachers at the schools also had access to one to two days of release time for professional development when the lab was at the school. As well, throughout the time that the lab was at a school, a technician was available for IT support and further training as needed. This additional support and training were major factors in the success of the mobile lab project. While portable computers and wireless LANs offer many advantages

to learning environments, these would not be realized without training for teachers, allowing them to become comfortable and confident in using this new technology.

Further Studies

To be on a quest is nothing more or less than to become an asker of questions.
- Sam Keen

As the study of using a wireless portable lab in elementary schools ends, it opens new possible areas of research.

Health Issues

An issue of concern for our school board and some others across North America was the perceived potential for health risks caused by the Radio Frequency (RF) signal. After the mobile lab had been to a school, the teachers decided that they would like to pursue having wireless installed as part of a full time solution. During a presentation to the school council, a parent, who is an engineer, raised a concern about potential health risks to students caused by the radiation emitted from the wireless access point and wireless cards in the computer. This concern was answered with some research of peer-reviewed literature that the system wireless committee for the Calgary Board of Education conducted. It was because of similar concerns from parents that wireless was not approved for educational use until last year. Health studies on this technology must be continually observed. The real concern will be with future wireless technologies that improve bandwidth by increasing the RF signal from 11mbs to 55 mbs. To do this requires a higher radiation output, and the health risk would need to be evaluated again.

Another health issue is ergonomics, studying how students use laptops and the effect of smaller screens on vision, for example. There is not currently a lot of peer-reviewed data available on laptop ergonomics related to elementary students.

Economic Feasibilities

Only generalizations can be made about the economic feasibility through this study, because wireless solutions can be implemented in a variety of ways. This project had a yearly support budget of about $30,000 and was used heavily in the elementary schools. The lab is now over three years old and is showing the regular wear and tear and developing obsolescence. Economic feasibilities will vary depending on the type of wireless installation chosen and how wireless is installed in the building. The Calgary Board of Education has settled on a fixed access point solution for all schools that will be using wireless technology, which has a higher initial implementation cost than the solution of the mobile lab. The lab had a mobile wireless access point that plugged into an existing Ethernet port.

Comparison of Laptop and Desktop Use

During the study it was interesting to see the differences between how teachers and students used the laptops to learn, think and play and how they used desktop computers. It would be worthwhile to pursue a closer look at this phenomenon, which might give us greater insights into how teachers and students learn with this technology. If teachers are more cognizant of how their students use laptops, teaching practice can be

modified or created to help bridge the gap between curriculum, technology and how students learn.

Other Wireless Devices

New wireless devices are beginning to be used in classrooms, devices like Palm Pilots, wireless calculators, GPS (Global positioning systems) and tablets. These will be replacing laptops very soon and have greater power. What impact will these devices have on elementary schools and ICT integration?

Future of AISI Lab and Direction of Calgary Board of Education

The AISI mobile lab initiative in the Calgary Board of Education was a three year project, which came to completion at the end of June 2003. The AISI lab will not be receiving another round of funding to support further research. AISI dollars are being redistributed into other major initiatives of the CLC that had originally initiated this project. The assets of the lab will continue to be used in schools that have innovative research initiatives that would benefit from using the wireless technologies or schools that still need some infrastructure support. For example, the lab will be going back to Glenbrook elementary in the fall. The school had a fire caused by arson, which destroyed the main gym and most of the upper floor of the school. In addition, the fulltime ICT specialist who coordinated the operations of the lab and facilitated professional development opportunities will no longer be in that role. The function of the eight ICT specialists will be changing in the next school year so they will no longer be available to provide professional development support to the lab.

Future Direction of Wireless in Schools and Society

When the research of wireless in education environments first started in the Calgary Board of Education with the initiative of Richard Tapp at Tom Baines Jr. High School and the founders of the mobile lab initiative in late 1999 and early 2000, very few schools in North America were using wireless, and schools that had laptops tended to have grants or were private schools. After attending the NECC (National Education Computer Council) Conference in Seattle, Washington at the end of June 2003, it was apparent that wireless is everywhere. Along with my presentation on wireless, at the conference many other papers and speakers described their wireless implementation findings. Of the 10,000 delegates, over 40% had their own laptops and accessed the wireless network that was available throughout all of the conference facilities. Many of the hotels in Seattle also offered wireless access to the Internet. A survey conducted by QED in November 2002 showed that 43% percent of the school districts surveyed are now using wireless devices.

In my new role as assistant principal of a large high school with 1600 students, we have gotten to the point where we cannot sustain the continual purchase of the digital devices that connect to the network. We are currently developing a plan for a wireless network that will allow the students of the future to bring their own devices and be authenticated by the wireless or wired network. Since the time of the ENIAC, the computing devices are becoming affordable and smaller. In our community many of the students already have laptops or other technology devices that could be connected to our network.

Future learning environments will no doubt have access to technologies that are smaller, more powerful and more flexible than desktop computers and wired infrastructures. Schools, although struggling financially, will continue to spend billions of dollars for these technologies. The US spent about $7.185 billion in 2002-03 (QED, 2002). However, the ability to create new knowledge and work in ways not yet imagined or realized with these new tools will depend on the creative uses that students and teacher apply.

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Appendix A

Parental / Guardian Consent Forms

University of Lethbridge - Faculty of Education, Graduate Studies
Parental / Guardian Consent Form

Principal Researcher: Michael J. Bester
ICT Curriculum Specialist, CLC4 Calgary Board of Education
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Parental / Guardian Consent Form

Research Project Title:	TECHNOLOGY INFRASTRUCTURE & DESIGN: THE IMPACT OF WIRELESS PORTABLE TECHNOLOGIES IN THE ELEMENTARY SCHOOL
Principal Researcher:	Michael J. Bester
Supervisor:	Dr. Marlo Steed, PhD.

Dear Parent / Guardian Consent Form:

I am conducting a study that looks at the impact of wireless portable computers on the Elementary school, professional development and the benefits for student learning. Your child's school has or is currently using the Calgary Board of Education's wireless portable lab for instructional and curriculum use. I am seeking consent from you to allow your child to participate in this study.

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your child's participation will involve. If you need more detail about the content of this form or about information not mentioned here please feel free to ask. Please take the time to read this carefully.

Purpose of this Study

The purpose of this study is to analyze the impact of portable wireless laptop computers on the instructional learning environments of elementary schools in the Calgary Board of Education. The results of the analysis from the research will form the basis of research reports that may be submitted for publication or presented in university classes, public lectures, doctoral dissertation, and academic conferences. This study will help provide the research community with some analysis of the benefits of wireless in elementary schools, as the use of wireless and portable technology becomes more prevalent in elementary classrooms and schools for teachers and students. This research will also be used to provide guidance and direction to the ICT curriculum specialists and administration of the Calgary Board of Education on best practices for the use of wireless technologies and portable computers in elementary schools and classrooms.

Research Methods

The proposed research method is to interview students who have or who are currently participating in the wireless portable lab project. As part of this research I will be interviewing

your child who has been using the portable lab to gain his/her perspective on what he/she thought about using the wireless laptops in the classroom. The interviews will be arranged at a time, which is convenient to your child's teacher and the school. The interview will be done at a time that will not impact the student's own learning or studies, but will be used as a way to help them reflect on their experiences of using wireless technologies and laptops. The interviews will be at most 15 minutes in length, and will be focused on what activities they did with the lab, and their perceptions around using technology.

The kinds of questions your child may be asked are:

- ☑ What can you do now with laptop computers that you could not do before?
- ☑ How did you use the laptop computers?
- ☑ How has working with the laptops helped your learning?
- ☑ It there anything you like better about laptops compared to your desktop computers?
- ☑ It there anything you do not like about laptops compared to your desktop computers?

Data will also be collected in the form of videotapes, audio-tapes and/or photographs of classroom activity, notes made by the researcher who will be present in the classroom, and photocopies and/or photographs of your child's work. Photographs of your child or their work may be published if you give consent.

The Calgary Board of Education portable lab system principal, the Calgary Board of Education ICT specialist and my supervisor(s) are the only people who will have direct access to identifying data (such as videotapes, photographs or transcripts that contain identifying information, etc.) Information that may identify your child (such as his or her name or school) will be stored separately from the videotapes and other identifying data.

Risks and Benefits

There are no anticipated risks of physical or emotional harm to subjects, and no deception. You are being asked for two things: permission to have your child participate in the study, and permission to have your child included in video or photographs for future presentations or publications both in the Calgary Board of Education and to external research bodies.

The results of the analysis described above will form the basis of research reports that may be submitted for publication or presented in university classes, public lectures, doctoral dissertation, and academic conferences. Although it is impossible to guarantee absolutely that consumers of research reports associated with this study will not be able to identify individual participants or their professional organizations, the researcher and those who have access to the data will make every attempt to respect the privacy of participants in the study. That is, information will be reported in a summary form, rather than attributed to specific individuals. Also, the actual words of participants will only be used when the identity of the speaker cannot be readily determined and when the words convey meaning in a particularly useful way.

All data collected from the study whether print / digital, audio, video or picture will be archived in their original form an kept at the Calgary Board of Education for a period of five years after the completion of the study. As well, interview, focus group, and survey data will be stored for the same period in a format that allows participants to remain anonymous and will be locked for security. Data in print form will be destroyed upon completion of the study and data in electronic form will be protected by security codes and/or locked storage containers.

You may withdraw your child from the study at any time without giving a reason, either by contacting your child's school or by contacting the researcher, Michael Bester, at 860.4501. They will still be able to participate in using the wireless laptops, as this is part of a curriculum activity of the school. The Calgary Board of Education sponsors the portable lab and your child's principal has asked for the lab to be used in the curriculum work of the teachers and students. Withdrawing from the study will not have any adverse effects on your child's relationship with the school or any adverse affects on their marks.

I very much appreciate your assistance in this study. If you have any questions please feel free to call me at (403) 860-4501, or email me at mbester@Calgary Board of Education.ab.ca. Also feel free to contact the supervisor of the study, Dr. Marlo Steed, at (403) 329-2189 marlo.steed@uleth.ca. You can also contact the chairperson of the University of Lethbridge Faculty of Education Human Subject Research Committee, Dr. Rick Mrazek, (403) 329-2452 mrazek@uleth.ca for additional for additional information.

Sincerely,

Michael J. Bester
Principal Researcher
ICT Curriculum Specialist, CLC4
Calgary Board of Education

PARENT / GUARDIAN CONSENT FORM
(Please Return to Your Child's School)

Research Project Title:	TECHNOLOGY INFRASTRUCTURE & DESIGN: THE IMPACT OF WIRELESS PORTABLE TECHNOLOGIES IN THE ELEMENTARY SCHOOL
Principal Researcher:	Michael J. Bester ICT Curriculum Specialist, CLC4 Calgary Board of Education (W) 403.860.4501 (H) 403.282.4539 Email: mbester@cbe.ab.ca
Supervisor:	Dr. Marlo Steed, PhD.

Your signature on this form acknowledges that you understand the information regarding participation of your child in the research project. In no way does this waive your legal rights nor release the researcher, sponsors, or involved institutions from their legal or professional responsibilities. Please note that all information will be handled in a confidential and professional manner. You also have the right to withdraw your child from the study without prejudice at any time. If you choose to do so, please indicate your willingness to allow your child to participate by signing this letter in the space provided below, and return the letter to the school with your child.

I agree and consent to allow my child, _____,
Child's Name (Please Print)

YES	NO	Items of Consent
☐	☐	To participate in this research study and be interviewed or viewed in the class.
☐	☐	To be visually portrayed in the work, and/or in any revision, adaptation or reproduction of it in analog and digital form by the researcher and Calgary Board of Education.
☐	☐	To have sample(s) of his/her work shared or published as a result of this research. All identifiable names will not be published.

I will not make claims of any kind against the researcher, or anyone acting under the authority of the Board, in any way related to the use, copying, publication, exhibition or distribution of the Work or to my portrayal in the Work or any future production using all or portions of my portrayal in the Work or any revision, adaptation or reproduction of any of them in any form.

Name of Parent/Guardian_____

Signature: _____ Date: _____

The Graduate Studies Office
University of Lethbridge - Faculty of Education
4401 University Drive Lethbridge, AB T1K 3M4 (403) 329-2425 fax: (403) 329-2252

Principal Researcher: Michael J. Bester
ICT Curriculum Specialist, CLC4 Calgary Board of Education
Work: 403.860.4501 Home: 403.282.4539 Email: mbester@cbe.ab.ca

Consent Form:	**Educator / School Support Staff**
Research Project Title:	**TECHNOLOGY INFRASTRUCTURE & DESIGN: THE IMPACT OF WIRELESS PORTABLE TECHNOLOGIES IN THE ELEMENTARY SCHOOL**
Principal Researcher:	**Michael J. Bester**
Supervisor:	**Dr. Marlo Steed, PhD.**

Dear Educator / School Support Staff:

I am conducting a study that looks at the impact of wireless portable computers on the Elementary school, professional development and the benefits for student learning. Your school has or is currently using the Calgary Board of Education's wireless portable lab for instructional and curriculum use. I am seeking consent from you to participate in this study.

This consent form is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you need more detail about the content of this form or about information not mentioned here please feel free to ask. Please take the time to read this carefully.

Purpose of this Study

The purpose of this study is to analyze the impact of portable wireless laptop computers on the instructional learning environments of elementary schools in the Calgary Board of Education. The results of the analysis from the research will form the basis of research reports that may be submitted for publication or presented in university classes, public lectures, doctoral dissertation, and academic conferences. This study will help provide the research community with some analysis of the benefits of wireless in elementary schools, as the use of wireless and portable technology becomes more prevalent in elementary classrooms and schools for teachers and students. This research will also be used to provide guidance and direction to the ICT curriculum specialists and administration of the Calgary Board of Education on best practices for the use of wireless technologies and portable computers in elementary schools and classrooms.

Research Methods

The proposed research method is to interview or survey educators and school support staff who have or who are currently participating in the wireless portable lab project. As part of this research I will be interviewing or surveying educators who have been using the portable lab to gain their perspective on what they thought about using the wireless laptops in the classroom. The interviews will be arranged at a time, which is convenient to your schedule. The interviews will be at most 15 minutes in length, and will be focused on what activities you did with the lab, and your perceptions around using technology. The surveys will ask the same questions as the interview. You will only be asked to participate in either an interview or a survey.

The kinds of questions you may be asked are:

Data will also be collected in the form of videotapes, audio-tapes and/or photographs of classroom activity, notes made by the researcher who will be present in the classroom, and photocopies and/or photographs of your students' work. Photographs may be published if you give consent.

The Calgary Board of Education portable lab system principal, the Calgary Board of Education ICT specialist and my supervisor(s) are the only people who will have direct access to identifying data (such as videotapes, photographs or transcripts that contain identifying information, etc.) Information that may identify you (such as your name or school) will be stored separately from the videotapes and other identifying data.

Risks and Benefits

There are no anticipated risks of physical or emotional harm to subjects, and no deception. You are being asked for two things: permission to participate in the study, and permission to be included in video or photographs for future presentations or publications both in the Calgary Board of Education and to external research bodies.

The results of the analysis described above will form the basis of research reports that may be submitted for publication or presented in university classes, public lectures, doctoral dissertation, and academic conferences. Although it is impossible to guarantee absolutely that consumers of research reports associated with this study will not be able to identify individual participants or their professional organizations, the researcher and those who have access to the data will make every attempt to respect the privacy of participants in the study. That is, information will be reported in a summary form, rather than attributed to specific individuals. Also, the actual words of participants will only be used when the identity of the speaker cannot be readily determined and when the words convey meaning in a particularly useful way.

All data collected from the study whether print / digital, audio, video or picture will be archived in their original form an kept at the Calgary Board of Education for a period of five years after

the completion of the study. As well, interview, focus group, and survey data will be stored for the same period in a format that allows participants to remain anonymous and will be locked for

security. Data in print form will be destroyed upon completion of the study and data in electronic form will be protected by security codes and/or locked storage containers.

You may withdraw from the study at any time without giving a reason by contacting the researcher, Michael Bester, at 860.4501. You will still be able to participate in using the wireless laptops, as this is part of a curriculum activity of the school. The Calgary Board of Education sponsors the portable lab and your principal has asked for the lab to be used in the curriculum work of the teachers and students. Withdrawing from the study will not have any adverse effects on your relationship with the school.

I very much appreciate your assistance in this study. If you have any questions please feel free to call me at (403) 860-4501, or email me at mbester@Calgary Board of Education.ab.ca. Also feel free to contact the supervisor of the study, Dr. Marlo Steed, at (403) 329-2189 marlo.steed@uleth.ca. You can also contact the chairperson of the University of Lethbridge Faculty of Education Human Subject Research Committee, Dr. Rick Mrazek, (403) 329-2452 mrazek@uleth.ca for additional for additional information.

Sincerely,

Michael J. Bester (Principal Researcher)
ICT Curriculum Specialist, CLC4
Calgary Board of Education
Work: 403.860.4501 Home: 403.282.4539
Email: mbester@Calgary Board of Education.ab.ca

Educator / School Support Staff CONSENT FORM

(Please return this Consent Form to the office Secretary, Bryce Roberts or Michael Bester)

Research Project Title: TECHNOLOGY INFRASTRUCTURE & DESIGN: THE IMPACT OF WIRELESS PORTABLE TECHNOLOGIES IN THE ELEMENTARY SCHOOL

Principal Researcher: Michael J. Bester
ICT Curriculum Specialist, CLC4
Calgary Board of Education
Work: 403.860.4501 Home: 403.282.4539
Email: mbester@cbe.ab.ca

Supervisor: Dr. Marlo Steed, PhD.

I agree and consent:

YES	NO	Items of Consent
☐	☐	To participate in this research study and be interviewed or viewed when working with my students or using the wireless portable lab in professional development activities.
☐	☐	To be visually portrayed in the work, and/or in any revision, adaptation or reproduction of it in analog and digital form by the researcher and Calgary Board of Education.

I will not make claims of any kind against the researcher, or anyone acting under the authority of the Board, in any way related to the use, copying, publication, exhibition or distribution of the Work or to my portrayal in the Work or any future production using all or portions of my portrayal in the Work or any revision, adaptation or reproduction of any of them in any form.

Name _____

Signature:_____ Date:_____

Appendix B

Surveys

Mobile Wireless Computer Survey
Teacher / Administrator

Grade Level Taught: _____
Years of Teaching Experience: _____
School: _____
Date: _____

1. What challenges do you currently have in implementing the ICT program of studies in your elementary class / school?

2. How does your current technology provide purposeful opportunities to integrate with the curriculum?

3. In what ways did the use of wireless technology and laptops make a difference in your classroom / school?

   - How did it impact the students' ability to work together or independently?
   - How did using this technology effect classroom supervision and management strategies?
   - How did laptops impact your existing classroom infrastructure? Example, use of space.
   - How did the laptops impact the use of time in the instructional environments?

4. How did having wireless LAN technology and laptops affect your teaching practice compared to using existing school lab or classroom desktop computers?

5. How were the students able to use the laptops differently for learning compared to the school computer lab or stationary classroom desktop computers?

6. Describe some experiences that you and your students had with the laptops. Please provide positive and challenging experiences.

7. How did having access to the laptops improve your ability to integrate the ICT outcomes into the core curriculum?

8. What are the advantages and limitations of providing students with wireless laptops that you noticed?

9. How did you grow professionally from this experience? How would having access to laptop affect your work and professional development?

10. Other comments, observations, concerns or suggestions for future research…

Mobile Wireless Computer Survey
Student

Grade: _____
Gender: _____
School: _____
Date: _____

1. What can you do now with laptop computers that you could not do before?

2. How did you use the laptop computers?

3. How has working with the laptops helped you developed new ideas or helped you in school?

4. It there anything you like better about laptops compared to your desktop computers?

5. It there anything you do not like about laptops compared to your desktop computers?

Appendix C

AISI Survey

CLC4 MOBILE LAB PRE TEST / POST TEST SURVEY

AISI 689 – Mobile Computer Lab Project
3030 CALGARY SCHOOL DISTRICT NO.19
Collaborative Learning Community 4

AISI Office Use Only
Date: _____
School: _____
☐ Pre Test
☐ Post Test

The CBE AISI System Principal and the Calgary Board of Education authorize this Survey for use. This survey is one form of data collection that will be used during this elementary schools involvement in the CLC4 Mobile Lab Project. Throughout the time the portable lab is here the Mobile Lab Team will be collecting data for the purposes of reporting, measuring the impact of this project, and identify areas to improve this AISI initiative. All Survey information from this form is kept confidential and secured and will only be used in summary form when reporting to CBE and Alberta Learning.

(Please Circle Appropriately)

Gender: Male or Female **Age:** 20-25 / 26-34 / 35-49 / 50+ **Position**: Support Staff, Teacher, Administrator
Do You Have a Home Computer: PC / Windows / Apple / None **Years of Experience:** 1-5 / 6-11 / 12 –19
Do you have an Internet connection at home? YES / NO **Grade Level Taught**: K-2 / 3-4 / 5-6

Please check the box next to the question that best reflects your response.	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
1. Technology can be used to make a difference in students learning.				
2. I have the necessary knowledge, skills and attitudes in order to meet the objectives of the ICT program of studies. (6.A)				
3. My students have the necessary knowledge, skills and attitudes in order to meet the objectives of the ICT program of studies. (6.B)				
4. My students are very comfortable when using technology for curriculum work.				
5. I believe that technology can improve students' literacy.				
6. I am comfortable learning about and using technology				
7. I would like to integrate more technology into my professional work				
8. I would like to integrate more technology into my classroom teaching.				
9. I feel comfortable helping others in the school with technology.				
10. I take personal time to learn and practice technology skills.				
11. I feel comfortable asking others in the school for help with technology.				
12. I believe that wireless LAN technologies and portable computing will more greatly facilitate the integration of ICT, compared to the traditional lab and wired desktop computers.				
13. I am comfortable in knowing how to assess how well my students are accomplishing the ICT outcomes.				
14. It is difficult finding the time to use technology in the curriculum.				
15. I feel comfortable using technology in my teaching practice to improve student's ability to learn.				

Please refer to next page for questions☺

CLC 4 Portable Lab Pre-Test Questions
Continued . . .

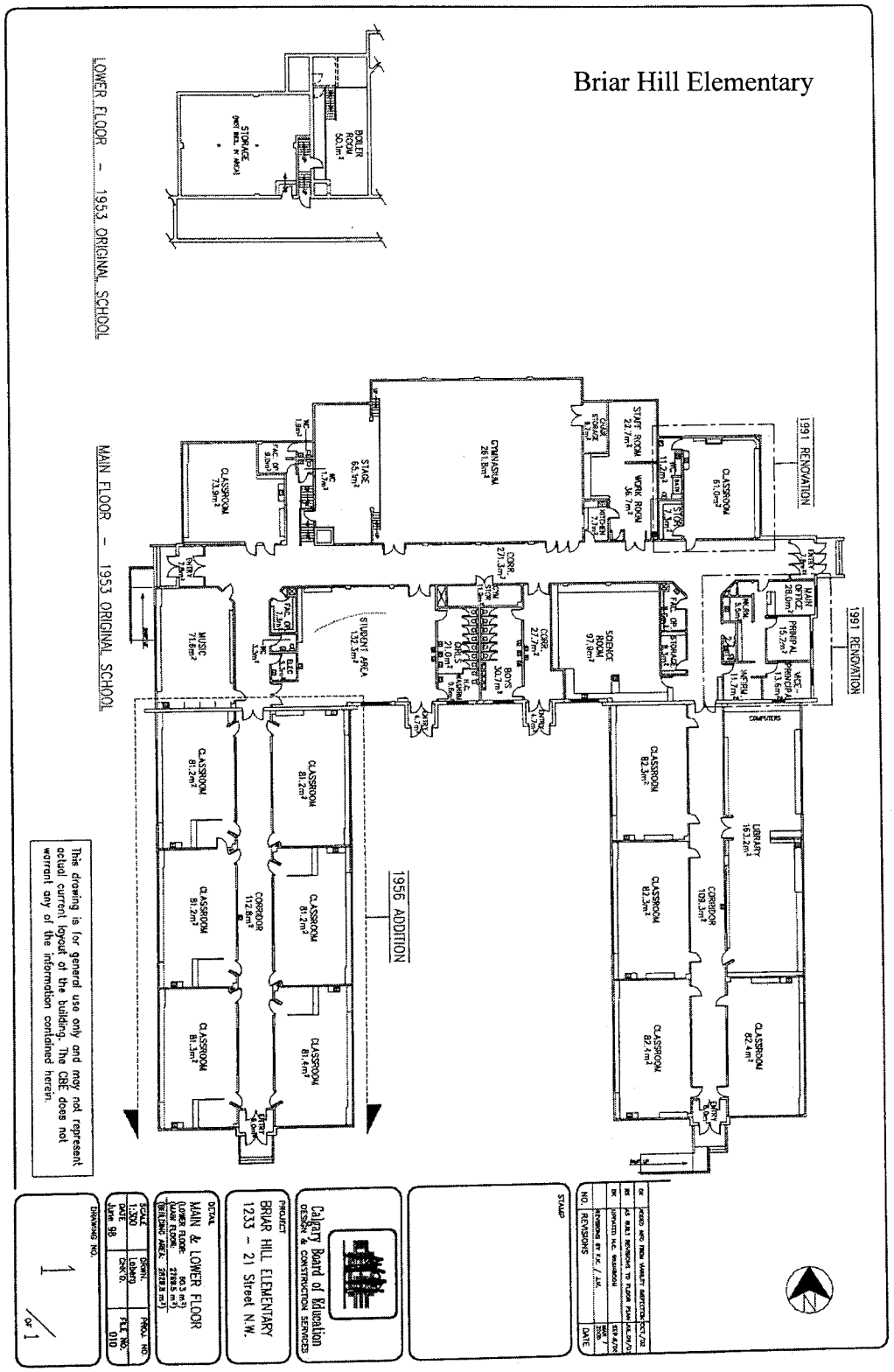
1. I would really like to use the lab to…
    a. With students
    b. For my own learning
    c. Other
2. It would really help me to make good use of the lab if I knew more about…
3. I believe the lab will the provide the following for the learning community…
4. I wonder that while the lab is here, if I could…
5. I anticipate the lab will make a difference in the following ways while at our school…

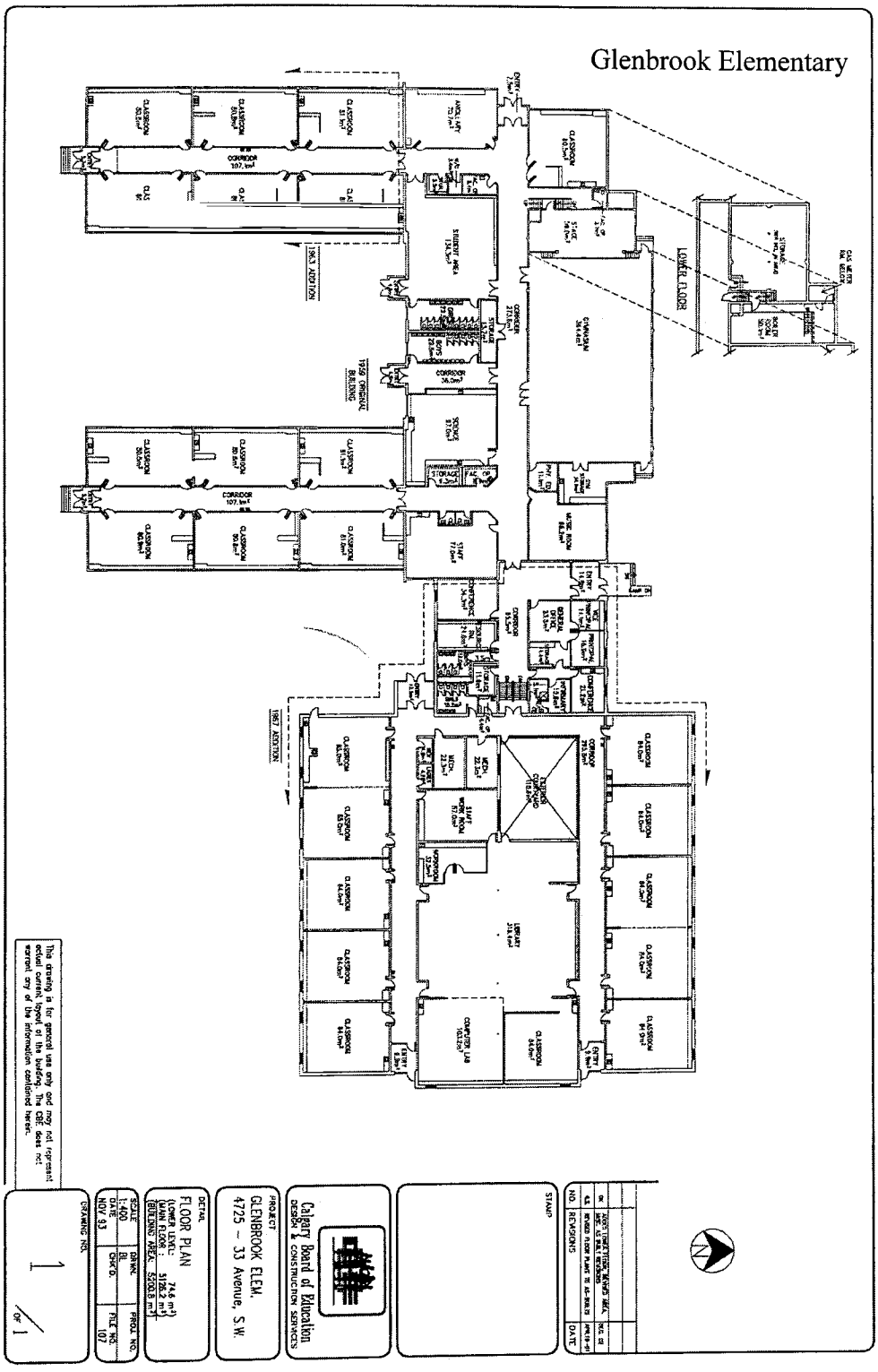
CLC 4 Portable Lab Post-Test Questions
Continued . . .

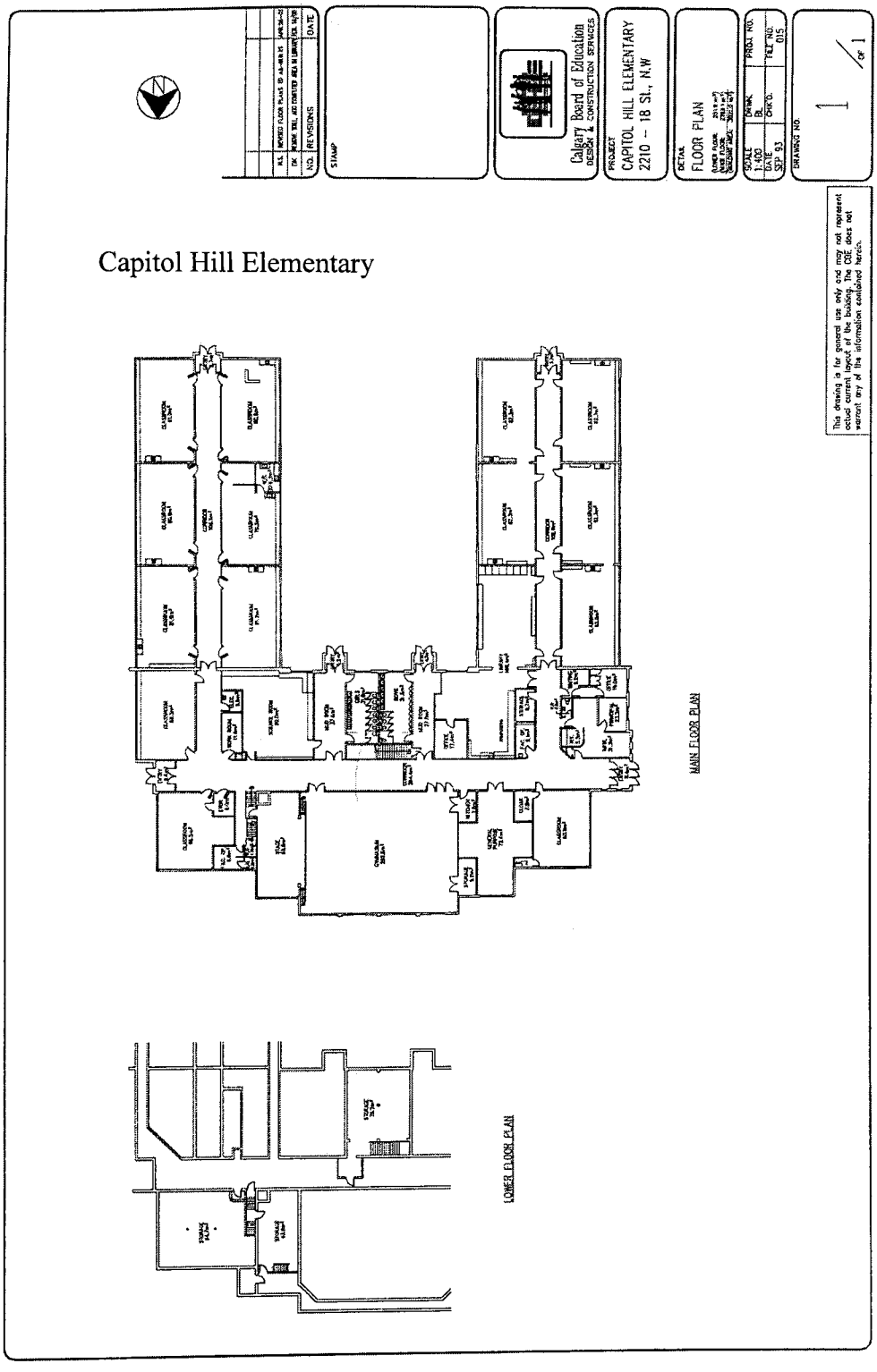
1. What did you like about having the lab?
2. How did this portable lab experience benefit student learning?
3. How did you grow professionally from this experience?
4. What benefits did the portable lab provide for implementing technology into the curriculum, why?
5. Other comments or observations…

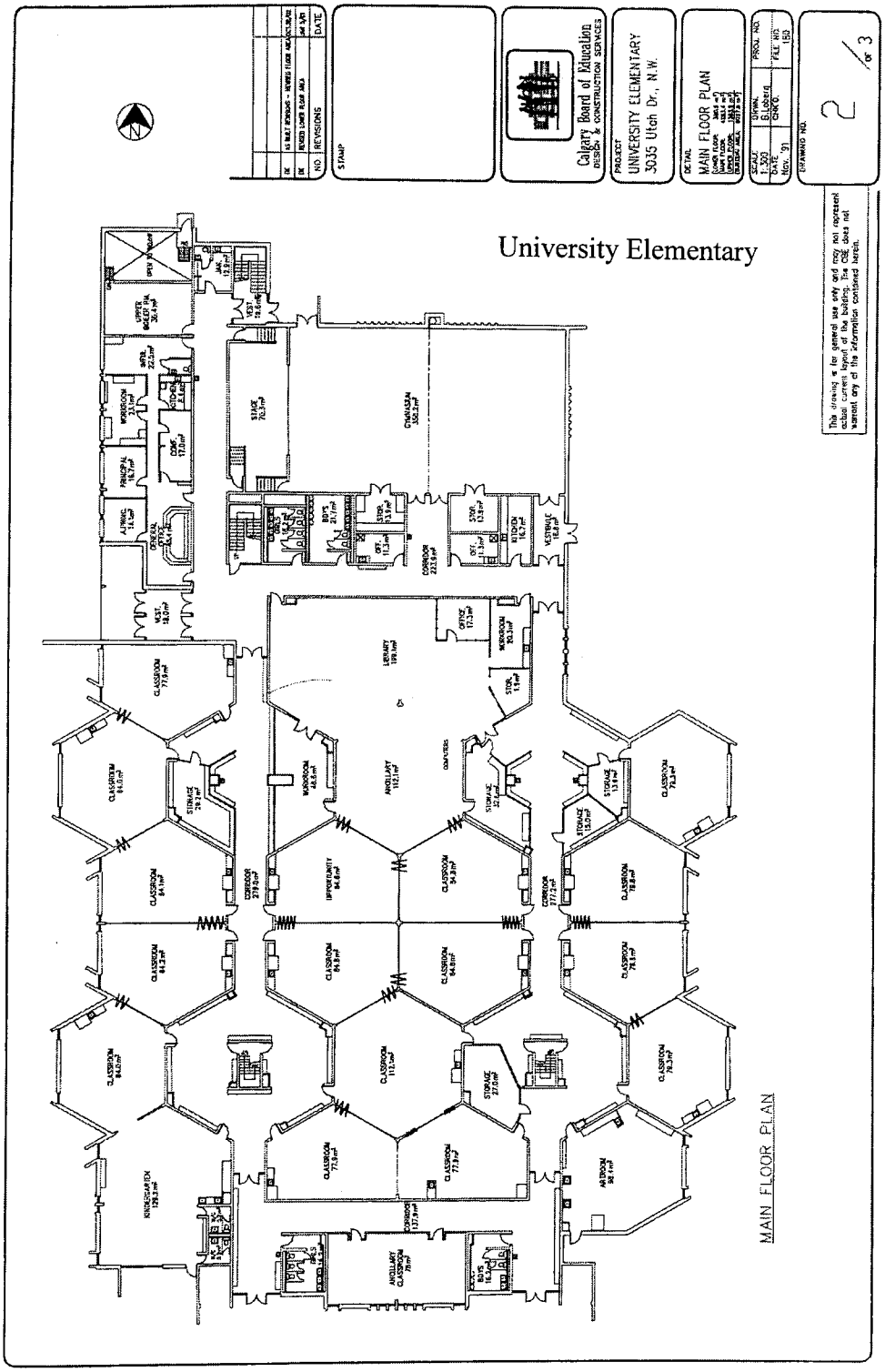
Appendix D

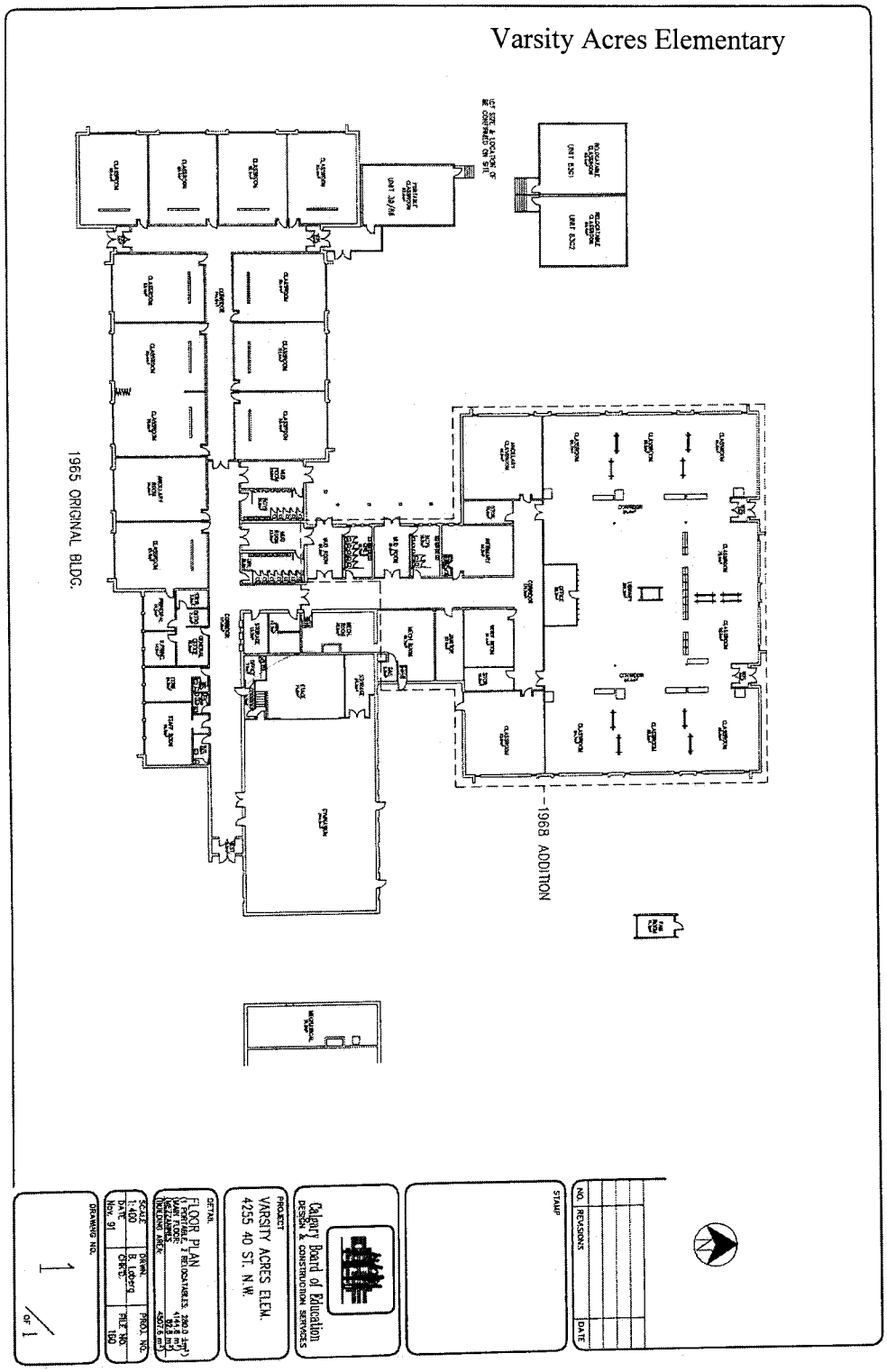
Blueprints of School Layouts

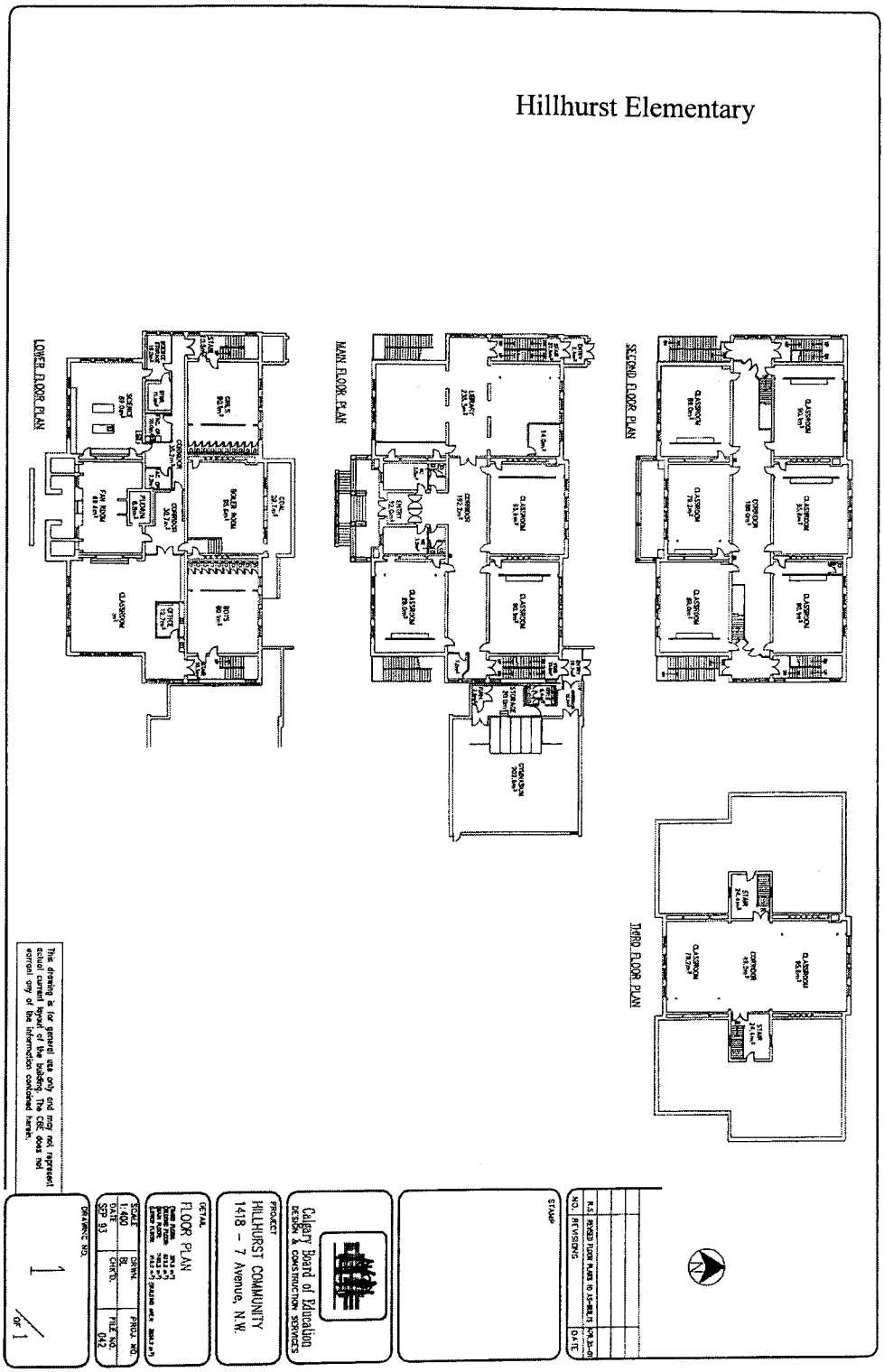


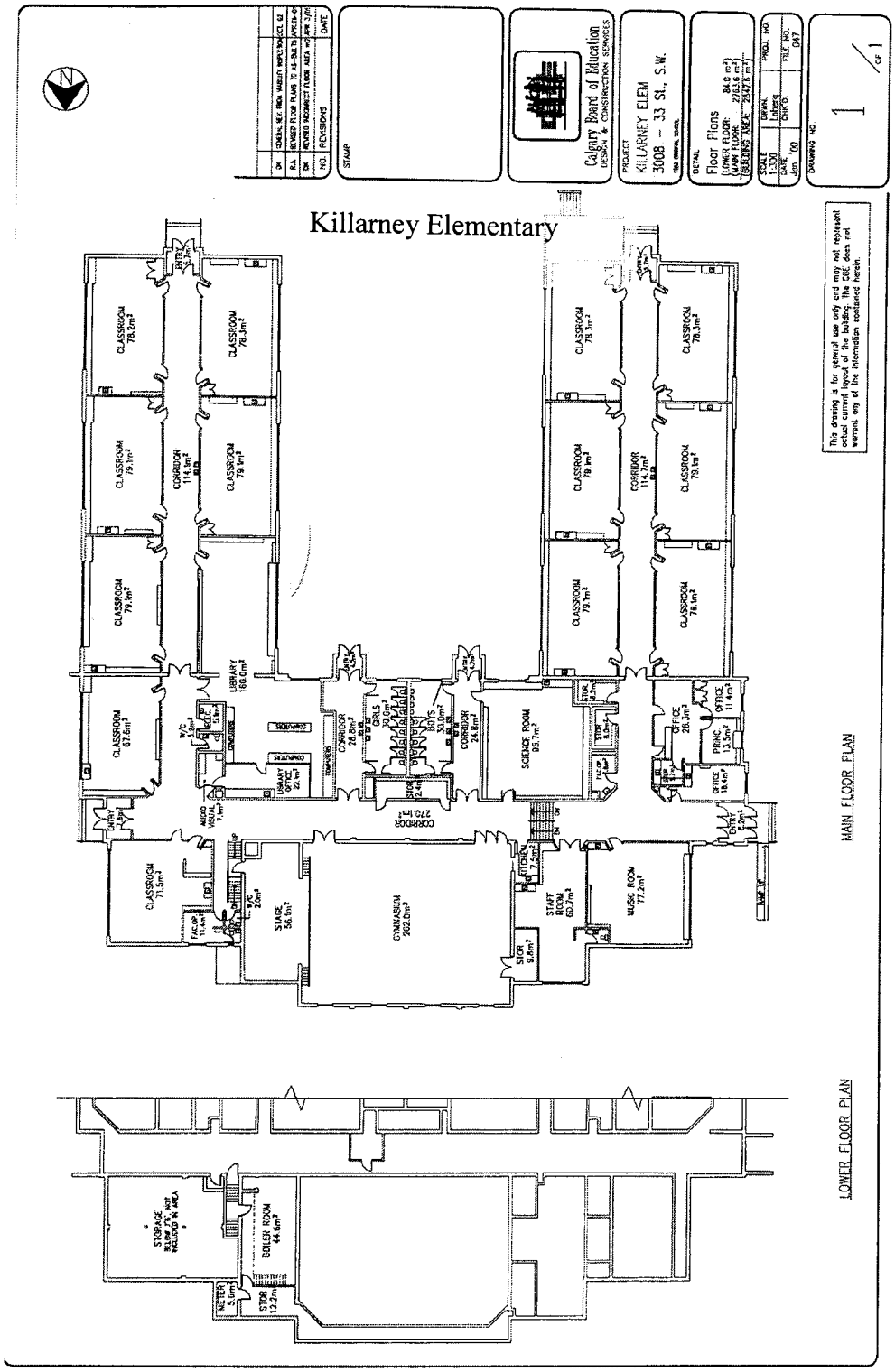

Glenbrook Elementary
LOWER FLOOR
1963 ADDITION
1956 ORIGINAL BUILDING
1967 ADDITION
Calgary Board of Education
DESIGN & CONSTRUCTION SERVICES
PROJECT
GLENBROOK ELEM.
4725 – 33 Avenue, S.W.
DETAIL
FLOOR PLAN
STAMP
NO. REVISIONS
DATE
SCALE
1:400
DATE
NOV 93
DRAWN
BL
CHK'D.
PROJ. NO.
FILE NO.
107
DRAWING NO.
1
OF 1
This drawing is for general use only and may not represent actual current layout of the building. The CBE does not warrant any of the information conferred hereon.


Calgary Board of Education
DESIGN & CONSTRUCTION SERVICES
PROJECT
CAPITOL HILL ELEMENTARY
2210 - 18 St., N.W
DETAIL
FLOOR PLAN
SCALE
1:400
DATE
SEP 93
DRAWN
B.
CHKD.
PROJ. NO.
TELE NO.
015
DRAWING NO
1
of 1
STAMP
REVISIONS
DATE
This drawing is for general use only and may not represent actual current layout of the building. The Board does not warrant any of the information contained hereon.
Capitol Hill Elementary
MAIN FLOOR PLAN
LOWER FLOOR PLAN


University Elementary
MAIN FLOOR PLAN
Calgary Board of Education
DESIGN & CONSTRUCTION SERVICES
PROJECT
UNIVERSITY ELEMENTARY
3035 Utah Dr., N.W.
DETAIL
MAIN FLOOR PLAN
DRAWING NO.
2
of 3
This drawing is for general use only and may not represent actual current layout of the building. The CBE does not warrant any of the information contained herein.


Varsity Acres Elementary
1965 ORIGINAL BLDG.
1968 ADDITION
Calgary Board of Education
DESIGN & CONSTRUCTION SERVICES
PROJECT
VARSITY ACRES ELEM.
4235 40 ST. N.W.
FLOOR PLAN
SCALE
1:400
DATE
Nov. 91
DRAWN
B. Lobsig
CHK'D
PROJ. NO.
DRAWING NO.
1
OF 1
NO.
REVISIONS
DATE
STAMP


Hillhurst Elementary
LOWER FLOOR PLAN
MAIN FLOOR PLAN
SECOND FLOOR PLAN
THIRD FLOOR PLAN
Calgary Board of Education
DESIGN & CONSTRUCTION SERVICES
PROJECT
HILLHURST COMMUNITY
1418 - 7 Avenue, N.W.
DETAIL
FLOOR PLAN
STAMP
NO. REVISIONS
DATE
SCALE
1:100
DATE
SEP 83
DRAWN
CHKD.
PROJ. NO.
FILE NO.
042
DRAWING NO.
1
OF 1
This drawing is for general use only and may not represent actual current layout of the building. The CBE does not warrant any of the information contained herein.


Killarney Elementary
Calgary Board of Education
DESIGN & CONSTRUCTION SERVICES
PROJECT
KILLARNEY ELEM
3008 – 33 St., S.W.
DETAIL
Floor Plans
LOWER FLOOR 840 m²
MAIN FLOOR 2761.6 m²
BUILDING AREA 2847.6 m²
SCALE 1:300
DATE Jan '00
DRAWN Libers
CHK'D
PROJ. NO
FILE NO. 047
DRAWING NO 1 OF 1
This drawing is for general use only and may not represent actual current layout of the building. The CBE does not warrant any of the information contained herein.
MAIN FLOOR PLAN
LOWER FLOOR PLAN