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ABSTRACT

The human and organizational infrastructure that is required to support the efficacious use of technology by teachers in the classroom was studied in three elementary schools in Alberta, Canada. The resulting impacts on engaged student learning were also studied, and the usefulness of Alberta's Galileo Educational Network Association initiative for professional development and support in supporting the integration of technology in the classroom was evaluated. The investigation involved biweekly visits to the 3 schools from April to June 2000 and interviews with 30 teachers and 48 students in grades 1 through 7. Administrators and teachers expressed complete satisfaction with the Galileo Network's approach to onsite professional development and support. The interviews with students and observations show that the student learning tasks developed through the Galileo Network bore a close relationship to real world problems, and that they were complex and integrated. A narrative account of visits to one of the classrooms shows some of the constructivist approaches used under the Galileo Network's program. Findings show that the Galileo Network provided extensive professional development support to teachers and administrators at the three schools. Students were presented with opportunities to explore new questions, and they were introduced to new ways of using technology. Teachers implemented different learning and teaching strategies and also integrated new technologies with the support of the Galileo Network. (Contains 31 references.) (SLD)

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Building Different Bridges: Technology Integration, Engaged Student Learning, and New Approaches to Professional Development

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Introduction

To thrive in a changing world, school children must learn how to learn, how to think, and how to understand how technology works and what it can and cannot do. Classroom teachers hold the key to student success with technology, and represent an important factor in determining the quality of education. However, teachers cannot and should not be required to shoulder sole responsibility for effective technology integration in schools. The transformation of classroom technology from hardware, software and network connections into thinking tools for teaching and learning requires effective and enabling leadership by visionary and knowledgeable school administrators and boards, and effective, ongoing professional development and support for teachers.

The availability of technology in schools is improving, and more schools than ever before are connected to the Internet. However, despite province-wide investments in a technological infrastructure for schools, online resources, and some professional development, many teachers have not readily adopted technology for teaching and learning tasks. Rather than being seduced by current "blame the teacher" rhetoric about why technology use is not more widespread in schools, this investigation seeks to uncover compelling reasons why technology integration is a desired goal in the first place. It is essential to consider the impact on student learning when teachers take advantage of technology for their teaching tasks. Three questions guided this investigation into technology integration in three elementary schools:

- What does effective technology integration look like?
- To what extent can children be engaged in authentic learning tasks with ICT?
- How does professional development effectively support teachers to effectively integrate technology into teaching and learning?

A Provincial Context for Technology Integration

Alberta Learning (formerly Alberta Education), the provincial education ministry, has taken a strong stance on the importance of information and communications technology (ICT) in the education of Alberta's youth. Few educators are aware that, unlike science, language arts, and mathematics, the study of computer technology is legislated as part of the provincial school act. The School (Computer Instruction) Amendment Act, 1998: Section 25(1), clause (g) prescribes standardized objectives for the study of computer technology. By ministerial order, Alberta Learning has passed a *Teaching Quality Standard (TQS)* related to ICT integration that is applicable to the provision of basic education in Alberta. The TQS requires that teachers who hold an Interim Professional Certificate in Alberta demonstrate consistently that they understand the functions of traditional and electronic teaching and learning technologies, and that they know how to use and how to engage students in using these technologies to present and deliver content, communicate effectively with others, find and secure information, research, word process, manage information, and keep records (Alberta Education, 1997).

The curriculum standards branch of Alberta Learning approved the *Information And Communication Technology, Kindergarten To Grade 12 Interim Program Of Studies* (Alberta Education, 1998) in June 1998 and optional implementation began in September 1998. Versions of the program of studies were piloted and refined by classroom teachers since 1996. The intent of the ICT learning outcomes is that students should have the knowledge, skills and attitudes that will serve them well for entry-level work, for further study and for lifelong learning, and that will serve them well as they strive to become inquisitive, reflective, discerning and caring persons (Alberta Education, 1998). With respect to fundamental understandings, students must be prepared to understand, use and apply technologies in effective, efficient and ethical ways. Mandated implementation commenced September 2000; the ICT Program of Studies is to be fully implemented by June 2003. Technology integration is meant to be cross-curricular, not treated as a course or topic in and of itself. The role of technology in schools in best practice is receiving a great deal of attention (Alberta Learning, 1999). The requirement that technology has a role is also creating a great deal of anxiety for educators across Alberta.

Technology and Educational Reform

For what reasons would a province's education department take such a strong stance on the role of technology in school? Alberta's Premier Ralph Klein provides an economic rationale in his response to the 1998 report by the Alberta Science and Research Authority (1998).

> In a dynamic global economy, the only way Alberta can sustain its high quality of living is by becoming a knowledge-intensive society, one that uses information and communications technology to a competitive advantage. This is our foundation. We will remain competitive and continue to make the most effective use of our resources. Albertans recognize the contributions that ICT can make to their quality of life and career.

In part, at least, the case for technology is being based upon Alberta's strategic and economic response to the shift from an industrial society to a knowledge-intensive one. A historical perspective may promote a better understanding of the tremendous impact that a shift from an industrial to an information age is having on educators and students.

In their book, *Teaching with Technology*, Norton & Wiburg (1999) focus first on the evolution of information and communications technology through the ages. Their story begins with the ancient Greeks who debated the invention of the alphabet and feared the use of letters might lead to a decline in the capacity of humans to use their memory and to an erosion of truth. In spite of these fears, the technology of letters changed the Greek oral culture into a scribal culture. Gutenberg's invention of the printing press in 1452 brought about radical changes in the conditions of intellectual life in Western Civilization. The printing press changed a scribal culture into a print culture. And as a consequence, editors and printers standardized textual representation and develop a communications medium that was mass produced and accessible to all. Norton & Wiburg (1999) posit that in the second half of the 20th century, with the invention and spread of the electronic technologies, yet another revolution is occurring. "The reinvention of knowledge because of the computer is already occurring and is changing our life options and the kinds of educational opportunities required for students to succeed in this new knowledge environment" (Norton and Wiburg, 1998, 1).

Each new technology, the alphabet, the printing press, and electronic technologies, has profoundly changed the way that humans come to know about and interact with knowledge. Schools are populated with children who often have a better understanding of major information and communications technologies than many of the adults charged to teach them. Children have grown up with communication technology as a natural part of their landscape; many teachers and parents, however, have not (Tapscott, 1997).

Classroom teachers face a formidable task in reinventing schools and classrooms for a world transformed by information and communications technologies. Public education, as most have experienced it, was developed to meet the needs of an industrial, print-based age. For more than a century, knowledge and learning activities in school have shared dominant characteristics of that larger culture: sequential, hierarchical, linear, externally determined and controlled, and compulsory for all. Perhaps because of societal shifts and changes in response to a major new communication medium, the topic of technology for teaching and learning is fast emerging as one of the forces leveraging educational reform.

The forceful impact of technology is, in part, related to shifting power structures in schools and changing teacher and student roles brought about by widespread access to electronically published information. For example, one of the provincial learner outcomes is "to seek alternative viewpoints, using information technologies" (Alberta Education, 1998). Access to the World Wide Web means that teachers, school boards, and the province no longer have exclusive control over the type and flow of information into the classroom. Students can access a much wider range of information and expertise via their internet connection than were practically available using conventional means. At least, that is the potential impact of the world wide web. To regain control over the information available to schools, many school boards promote and require lock-downs and lock-outs using security software that make internet access absolutely useless to students and teachers (Males, 2000).

Clifford, Friesen & Jacobsen (1998) describe the shifting nature of power and learning in classroom contexts when teachers put the power of adult tools in the hands of children. A number of researchers argue that there is a qualitative difference in how adults and children approach, or confront technology (Goldman-Segall, 1998; Howard, 1994; Jonassen, Peck & Wilson, 1999; Norton & Wiburg, 1999; Papert, 1980, 1993, 1996). Teachers, who were trained to deliver instruction based upon an industrial age model, "knowledge packaging and transfer from expert-to-novice", are under tremendous pressure to integrate a major information and communications technology that can shift the balance of power in the classroom, and change teacher and student roles forever.

Leaping into the knowledge age appears to be less about technology integration *per se*, and more about the fundamental changes to teaching and learning that are enabled and required by the new medium. The learning environment of the information and communication age calls many of the assumptions of the print-based models of schooling and teaching into question. The emerging technologies require thoughtful teachers to face fundamental issues and ask essential questions. For example, what is the nature of literacy in a hypermedia environment? Composing and engaging with text and graphics in this environment calls for fundamentally different skills, dispositions and critical abilities, many of which are undervalued and some of which are actively discouraged by traditional text-based orientations in school. How do teachers negotiate these new expectations?

Goldman-Segall (1998) describes the fundamental cultural, pedagogical, and power shifts that occur when digital technologies are used by children to become knowledge producers rather than knowledge consumers. Unlike the predominantly broadcast media of the past, digital technologies enable those with access to publish and exchange text, graphics, animation, sound and video on public web servers. Goldman-Segall (1998) builds upon the shift in technology from broadcast to interactive media to promote the idea of the learner constructing instead of an expert instructing. The shift from instructionist to constructivist approaches to designing learning environments when using digital media represents a shifting paradigm that is enabled and required by the infusion of ICT into core areas of the curriculum.

At issue for teachers, then, is not simply whether technology offers a better way to learn, or not. ICT represents a major technological and communications revolution; ICT changes forever how people manage, exchange, and share information. The integration of technology into teaching and learning demands and requires us to question conventional methods and approaches, enables shifts in power relations and roles, and puts new knowledge sharing capabilities into the hands of children and adults alike. ICT requires a reconsideration of changes that will enable students to take advantage of unregulated on-line resources, and to contribute to and extend those resources as they share their knowledge with the world. The integration of ICT requires that pedagogical, assessment and evaluation structures be reconceptualized. How do educators evaluate the quality of the new knowledge and representations that children produce when there are many ways to be right, versus only one? How do teachers and students live and work in a learning environment in which time, distance, cultural differences and relations of power no longer divide us in traditional ways? Educators who are used to a tightly scheduled and timed school day, and strictly defined curricular units and grading, quite understandably feel a great deal of tension and discomfort when faced with the provincial mandate to welcome ICT and these changes into their classrooms.

Roadblocks on The Integration Highway

What are some of the factors that appear to limit the technology integration efforts of the average classroom teacher? In response to a recent survey by the Alberta Teachers Association Computer Council (2000), entitled "Technology Issues Facing the Classroom Teacher", teachers provided feedback on integrating technology with the curriculum. The majority of the 44 respondents were full time teachers (70%), and others were technician/administrators (18%), half time teacher/half time administrators (9%), and a part time teacher (2%). Forty-two of the respondents are in a regular classroom teaching setting, whereas one is in an independent study program within a school, and one is in a virtual school. The majority of respondents (59%) listed core classes (i.e., mathematics, language arts, science, social studies) as their main teaching assignment, while 29.5% listed computer, programming, and/or keyboarding technology classes, and 11% listed art, music, second language and/or shop option classes. The majority of respondents indicate that they taught a combination of grades (34%), while 25% teach grades 10 to 12, 18% teach grades 7 to 9 and also grades 4 to 6, and 4.5% teach primary grades K to 3.

Respondents were instructed to select the top two of six key issues that impact their attempts to integrate technology and curriculum (Table 1). Many teachers selected 3 or 4 key issues, which may be interpreted as an indication of the many issues and considerations that teachers believe impact their attempts to integrate technology across the curriculum.

Table 1. Technology Issues Facing the Classroom Teacher

Key Issue	**Chosen by (%) of Respondents**
Time for planning and development of ICT lessons	54.5
Insufficient hardware (computers/printers/...) In your teaching area	45.5
Technical support (maintaining hardware/supporting the network/installing software/...)	41
Professional in-service time/funding	38.6
Availability/cost of appropriate software	25
Connectivity and bandwidth to the internet	16

Of the six key issues, "time for planning and development of ICT lessons" was selected most often by teachers. Jacobsen (1998) found a similar result with faculty members who rated "insufficient time" as the biggest barrier to integrating technology for teaching and learning. The second highest rated issue, "insufficient hardware (computers/printers/...) in your teaching area", might be explained a number of ways: (i) there is not enough hardware in the school for students and teachers to use, (ii) early adopters or technologists believe there is not enough 'cutting edge' hardware in the school, or (iii) computers are located in labs, instead of in readily accessible teaching areas. The third highest rated issue, "technical support (maintaining hardware/supporting the network/installing software/...)" is complex, as it points to staffing, power, funding, and training concerns.

The fourth highest rated concern, "professional inservice time/funding" is an issue that receives a great deal of attention in the remainder of this paper. In many schools, teachers have adopted technology for tasks that closely match the ways in which they taught before - they lack understanding of how to take full advantage of the powerful and unique capabilities of ICT to enfranchise / emancipate their students' meaning making tasks (epistemology). Since the late 1970s and early 1980s, schools have invested billions of dollars in computers and networks for classrooms and libraries, and school districts have drafted various objectives and mandates to infuse technology into the curriculum. In spite of these vast investments in the technology boxes, wires and directives, schools and districts have largely neglected to invest in adequate and appropriate professional development for teaching staff. Teachers need professional development in order to bridge the gap between the presence of computers in school, and the effective use of information and communications technology for learning.

The mere presence of computers does not lead to reforms in educational practice. In schools that do have adequate technology, administrators are finding that a technology-driven, top-down "if you build it, they will come" approach to technology integration is simply not working. Wilson (1998) describes how teachers may covertly or overtly sabotage top-down efforts in his argument that it is important to involve teachers in the decision-making and planning for technology integration. Worse, when technology integration doesn't occur in presence of numerous computers, commentary shifts to a "blame the teacher" approach that casts educators as being too old, too resistant, and too scared/anxious to use computers with their students (Hodas, 1993).

Changed Approaches to ICT Professional Development

The type of professional development available for teachers who want to develop their capacity for technology integration has undergone some changes over time. The first efforts at professional development for ICT, which focused on the machines and learning technology skills, have been found to be largely ineffective for widespread adoption of technology for classroom applications. Teachers have long been able to access before and after school workshops on how to use the computer. This training often occurs at locations other than the school in which the teacher works. As for this style of teacher training on technology, the "drinking-from-a-firehouse-hit-and-run-three-hour-software-workshop" after school on Friday did not change practice in any meaningful ways on Monday.

The second wave of PD for ICT responded to the realization that the technology integration had less to do with the technology itself, and much more to do with approaches to teaching and learning. Workshops on teaching with technology, usually at some centralized location, helped to bring the tools together with the teaching issues. However, this approach, while accomplishing some skill development, largely fails to bring about the large-scale transformations in teaching practice that are being sought. One must consider that teachers are being asked to risk two large changes to their practice: 1) reformed pedagogical approaches and roles, and 2) technology integration. Transformed teaching practices will not occur as a result of three-hour workshops that are often decontextualized from the teacher's local context.

The third wave of situated professional development, consisting of onsite mentorship and support that responds to teacher's individual needs (as described in Stein, Smith, & Silver, 1999, and Swan, Holmes, Vargas, Jennings, Meier, & Rubenfeld, 2000) is the focus of the present case study of an Alberta initiative to provide leadership in ICT integration for teaching and learning.

Present Investigation

A growing number of teachers are very enthusiastic about adopting technology because of the potential of computer tools for their students. Goldman-Segall (1998) describes the changes in children's thinking and culture, and also the shifts in teachers' thinking about the nature of knowledge construction, in relation to digital media and communications technology. However, an evaluation of the success of educational technology still depends largely on how well a small number of early adopters make it work under conditions created by protective and enabling leaders (Yee, 1999), or in spite of conditions created by others. Technology is being used effectively by some teachers in some schools, and meaningful student learning is the result. Still, the gap between technology presence in schools and its widespread, effective use is too wide.

This investigation aims to better understanding the human and organizational infrastructure that is required to support the efficacious use of technology by teachers in the classroom, and the resulting impacts on engaged student learning. A second purpose was to better understand how Alberta's Galileo Educational Network Association (GENA), supports the work of skilled and enthusiastic teachers and administrators who are prepared and motivated to put technology to work for themselves and their students. GENA is a province-wide education reform initiative focused on the fundamental changes to teaching, learning and schooling that technology both enables and requires. They support teacher's technology integration efforts using innovative approaches to professional development. GENA supports transformational leadership and teaching with technology in Alberta by working on-site with teachers and students to create new images of teaching, student capabilities and staff development.

Essential Questions and Study Objectives

A number of questions guided this research on engaged student learning, technology integration, and new models of professional development, and several others emerged as schools were visited, and teachers and students were interviewed. Namely, to what extent does institutional culture, administrative leadership style, and professional development influence individual decisions about technology adoption for teaching? What conditions encourage or prevent the adoption of technology by teachers? What form of professional development enables teachers to make the fundamental changes to their practice that technology integration both demands and requires?

The investigation aimed to better understand the impact on student learning when teachers take advantage of technology for their teaching tasks. Three questions guided this investigation into technology integration in three Alberta elementary schools:

- What does effective technology integration look like?
- To what extent are children engaged in authentic learning tasks?
- How effective is on-site professional development for supporting teachers to effectively integrate technology into learning?

Theoretical Framework

This research is situated in literature about integrating technology for teaching and learning in education. What follows is a brief review of the diffusion of innovations research tradition, how adopter categories and the innovation-decision process is conceptualized theoretically, and how these concepts and models from Roger's (1995) theory can be applied in an investigation of administrator and teacher adoption patterns and characteristics.

Rogers (1995) defines an innovation as an idea, practice or object that is perceived as new by the individual, and diffusion as the process by which an innovation makes its way through a social system. An important conceptual and methodological issue is to determine the boundaries that define a technological innovation. Therefore, *instructional technology*, as defined in this investigation, includes several current types of computer-based applications and mind tools (Jonassen, Peck, and Wilson, 1999) used for synchronous or asynchronous teaching and learning tasks, the hardware on which these applications run, the peripherals, and network infrastructures.

According to Rogers' (1995) theory, the diffusion of an innovation usually follows a normal, bell-shaped curve when adoption is plotted over time on a frequency basis. The *time* element of the diffusion process allows us to generate diffusion curves and to classify adopters into categories. Diffusion curves allow us to compare the *innovativeness* of an individual or other unit of adoption with other members of a system. Because individuals in a social system do not adopt an innovation at the same time, *innovativeness* is the degree to which an individual is relatively earlier or later in adopting new ideas than other members of a social system. Adopter categories are useful for simplifying the complexity of adoption patterns in a social system by describing the central exemplar or summarization of five categories based upon innovativeness (i.e., innovators, early adopters, early majority, late majority, and laggards). For example, teachers who used text editors twenty years ago are described as having a higher degree of innovativeness than teachers who started using word processing yesterday. Jacobsen (1998) demonstrated how Roger's (1995) theory and conceptual models can be usefully employed in a cross-comparison of adoption patterns and faculty characteristics by discipline and by institution.

While Roger's (1995) adopter categories are useful to describe group characteristics and trends, there is a need for more focused and careful description of individuals within each category. The defining characteristics of each adopter category understate the uniqueness of the individual. Personal stories, or case histories, of adopters and non-adopters are better suited to capturing those elements or complex details that formal models may leave out. Roger's (1995) innovation-decision model provides a useful framework for investigating and analyzing the individual stories for the thoughts, values and beliefs of category members as they live through the implementation of an innovation.

The Innovation-Decision Process - An individual's decision to adopt an innovation is rarely an instantaneous act. Rather, it is a process that occurs over time, and consists of a series of actions, influences and decisions (Rogers, 1995). For example, it has been found that adoption or non-adoption of instructional technology by faculty members is influenced by larger social, cultural and political contexts that frame what and how individuals teach in classrooms, how they are supported and rewarded for their efforts, and the perceived value for students (Jacobsen, 1998).

Modes Of Inquiry

A case study research design, which uses qualitative research methodologies, put into practice Tornatzky & Klein's (1982) five recommendations for future diffusion research.

1. *Measure adoption and implementation.* Beyond capturing the time element of adoption, this investigation explores the process of using technology with students, and teachers' evaluation of the impact of changed approaches to learning.
2. *Include multiple sites for cross comparison.* Three different school sites are included in the evaluation to facilitate comparisons of what worked well, for who, under what conditions and why.
3. *Utilize replicable measures.* An analysis of data has been conducted using the 26 indicators of *engaged learning* and 22 indicators of *high technology performance* developed by the North Central Regional Educational Laboratory (1995).
4. *Study multiple innovations.* Both the integration of technology, and the changed approaches to teaching and learning that ICT demands and required, are subject to evaluation.
5. *Focus on organizational and individual settings.* Institutional, political, and social factors that influence the individual teacher's adoption decisions are evaluated.

Field Research

This research project was carried out concurrently at the three elementary schools that were involved with the Galileo Educational Network in 1999/2000. The investigation involved bi-weekly visits to schools from April to June 2000. Two schools served a kindergarten to grade 6 student population, and the third school included grades 7 and 8. The size of student population ranged from 175 in the smallest of the three schools to over 400 in the largest. The instructional staff size ranged from 9, including the principal, in the smallest school to approximately 25 in the largest school. The communities served by the three schools ranged from lower to middle income. Two schools were located in urban settings, and one was in a smaller, rural community.

Administrators, teachers and students generously gave of their time to participate in interviews, and also allowed investigators to observe their practice and use of technology in the classroom. A total of 30 teachers and 48 grade 1 to 7 students participated in interviews about technology integration, engaged learning, and involvement with the Galileo Educational Network. Interview and observation data has been analyzed using the 26 indicators of *engaged learning* and 22 indicators of *high technology performance* developed by the North Central Regional Educational Laboratory (1995). This framework for measuring effective learning with technology is organized into eight categories of learning and instruction: vision of learning, tasks, assessment, instruction, learning context, grouping, teacher roles, and student roles. The engaged learning indicators provide a much-needed lens through which the interview and observational data could be measured, evaluated and represented. Conversations with teachers, administrators and members of the Galileo Educational Network facilitated the development of a shared understanding and language from which to articulate the impact of professional development initiatives on technology adoption and student learning.

The remainder of this paper summarizes study findings in three sections. Excerpts from interviews with teachers and administrators are used to capture reflections on student learning, technology integration and the professional development initiatives. Section One is an overview of the relationship between the schools and the Galileo Educational Network. Section Two describes the specific nature of Galileo Network's on-site work with individual teachers. Section Three is a summary of findings on engaged student learning using North Central Regional Educational Laboratory's (1995) 26 engaged learning indicators as a conceptual framework.

Section I - Overview Of The Galileo Educational Network

The Galileo Educational Network works alongside teachers in schools and in school districts across Alberta to build their capacity to lead effective technology integration and new ways of teaching. Their approach to on-site professional development is focused on working at all levels of an organization in collaboration with school-based staff, parents, students and district administration in order to:

1. support the effective implementation of Alberta Learning's Information and Communication Technology (ICT) Program of Studies;
2. network staff with other educators committed to studying inquiry-based practices;
3. provide intensive classroom and school-based support to assist in infrastructure, professional development and curriculum planning;
4. facilitate the development of an assessment program for ICT, and
5. offer on-line support and follow-up assistance.

In addition to the support of school districts in Alberta, the work of the Galileo Educational Network is supported by a number of government, industry and community partners, including Alberta Learning, Alberta Science and Research Authority, Bennett Jones, Faculty of Education, University of Calgary, Faculty of Education, University of Lethbridge, Gallagher Education Foundation, IBM Canada, Ltd., Industry Canada SchoolNet, Institute for Professional Development, University of Alberta, Shaw Communications, Inc., and Stellarton Energy Corporation. The Galileo Educational Network publishes an extensive set of resources and documents on a publicly available web site: [On-line]. Available: http://www.galileo.org

Section II - On-Site Professional Development

This section provides a description of the principles underlying Galileo Network's on-site relationships with school divisions, administrators, teachers, parents and students. The Galileo Network responds to the unique culture of the school by working collaboratively with the entire school staff, with parents, with district technical support people, and district personnel. Galileo staff do not impose set methods or models on the school, or on individuals, but rather invite stakeholders to participate in the process of creating a learning environment at the school that is engaging and reflective of high technology performance. During initial conversations and planning work in each school site, GENA explores with the school staff their vision and goals for the coming year, and then meets with teachers to collaboratively plan projects for students. The Galileo Educational Network's approach to professional development is based upon relationship building; they work closely with teachers from their individual starting point, and are nonjudgmental. Individual teachers choose the extent to which they wanted to be involved with Galileo Network initiatives in the school and on-site professional development and support. Teachers selected the curricular areas that they want to focus on with their students.

During the 1999/2000 instructional year, the Galileo Educational Network provided professional development (PD) services to three schools in three school divisions. Although the agreement worked out with each school is unique, the general approach to onsite work is that the Galileo Network agrees to work on-site for approximately 80 days in each school. The PD days numbered approximately 240 in the three elementary schools in 1999/2000. The sheer number of professional development support days available in a Galileo school is tremendous compared to the average 3 to 6 days of PD that the average Alberta teacher can expect during an instructional year. To establish an idea of the scope of this PD initiative in its second year of operations, 2000/2001, the Galileo Educational Network has grown to include work in 11 schools across 5 school divisions. Based on the estimate of 80 days of professional development support, that may equal approximately 880 days of Galileo time over the year. Therefore, the staff necessary to sustain and grow the on-site work has grown officially from the original three (which consisted of two nationally recognized, expert teachers and a general manager) to eight, along with a number of part-time secondments in the schools themselves. Among the five additional staff in the second year are an administrative assistant, a certified network engineer who was formerly a teacher, and three more expert educators, who have been seconded from two school districts. Each of the five expert educators work on-site in the eleven schools several days per week.

Based on feedback from teaching and administrative staff, the Galileo Network teachers were responsive to the unique culture and community at each of the three schools involved in 1999/2000. Galileo Network teachers worked in classrooms with teachers who invited them to be there. Galileo Network teachers only worked with those teachers who were willing, ready and interested in working to integrate technology into teaching and learning, and did not impose set methods or models on an entire staff, or on individuals. The following examples provide images of the ways in which the Galileo teachers supported the work of teachers on-site in the three schools. The Galileo Network staff:

- worked with teachers, both individually and in teams, across all grade levels;
- worked with teachers to plan instruction, to plan demonstrations for the community and the press, and to organize celebrations of student work;
- modeled pedagogical methods with children (both singly and as a team) to enable the teacher to be a participant observer;
- worked with technology support staff in the school and at the district level as advocates and leaders;
- observed and worked alongside teachers using new methods and discussed the results with them afterwards;
- worked with teachers to design appropriate assessments of student work;
- gathered, organized and shared resources (often from their personal collection of books and articles, and also from collections of websites) with teachers and students;
- led professional conversations to build and extend teachers' understanding of fundamental teaching and learning issues;
- provided scholarly and intellectual mentorship;

- supplied on-going, on-site support, both pedagogical and professional, for risk-taking and innovative practice.

The Galileo Network respected each teacher's individual starting point, with both technology and innovative pedagogical methods. It is important to emphasize that unique relationships were formed with each teacher. Each one of the administrators and teachers interviewed described different ways in which they collaborated with the Galileo teachers. Galileo teachers worked with each teacher on a project or idea that the teacher identified or chose, and developed a different relationship with each teacher.

Instead of a preset model for working with teachers, the Galileo Network's relationship building is guided by principles of engaged student learning and high technology performance, and is responsive to the individual educator's teaching and learning situation and school context. For example, in one of the three schools, the technology infrastructure lagged far behind what was available in the two other schools. The Galileo teachers met with the entire school staff weekly throughout the first half of the school year planning and implementing projects that built and extended upon innovative teaching methods, and engaging in sustained dialogue about effective student learning. When the computers arrived in the spring, the entire staff was ready to make optimal use of the network with students. In one of the other schools, the technology infrastructure was state of the art, and the Galileo teachers focused on working with teachers who wanted to optimize student use of the computers and network for learning. In the third school, student use of the instructional computer lab, and distributed workstations, was at the productivity level. The Galileo teachers worked with the teachers in this school to develop projects for students that were inquiry-based, intellectually challenging and engaging.

The Galileo Network's approach is nimble, flexible, and changes in response to the individual teacher's ideas and requirements. Teachers were encouraged to prototype ideas and approaches "on the fly" through the onsite support of Galileo teachers. Educators' relationships with the Galileo teachers were of different levels of intensity. Some teachers worked very closely with the Network teachers to plan and implement technology rich, inquiry projects with their students. Others benefited from shorter-term relationships, questioning and watching how their colleagues worked with the Galileo Network in the first year, and through professional conversation about benefits of this type of work for student learning. One teacher observed:

"I've worked extensively with Galileo this year. I tried to take advantage of this opportunity as much as possible because I'm ready in my own teaching. I'm comfortable enough in my own teaching that if things don't work out I've got enough in my little bag of tricks that I can pull out and avert most disasters. Also, after 20 years of teaching, I know the curriculum so well that I know how to integrate things into the curriculum to make sure that I'm teaching the curriculum so it's a perfect place to be in to further my own learning".

To understand Galileo Network's approach to professional development in the three schools, one must understand that it is guided by principles of engaged learning and high technology performance, not by a predefined model or step-by-step approach to working with individual teachers. Instead, what is innovative about this approach is that it emerges from the relationship between Galileo teachers and each school teacher. When asked to describe the nature of their work with each teacher or group of teachers during 1999/2000, Dr. Pat Clifford and Dr. Sharon Friesen, the expert teachers who worked onsite, explained that their work with teachers

> *... really showed us very clearly that there is no model for doing this.... it's not models that make a difference, it's ideas that make a difference and it's relationships that make a difference. So it's in hearing what people want to do. It's just like teaching in a classroom where you work literally from where people are... because people can't be in any other place than where they are. You can't wish them to be somewhere else. They are where they are from the start. And so you listen to that... where's your opening? And then around the opening they provide for you, the job of the expert then, we think, is to say what could we put in place for this person, given who they are, what they want to accomplish, and what they're working with? So it looks different, as it ought to, for each person. We called it being responsive and... it's actually to say if you're going to have people work with kids in this way, you have to provide them, as teachers, a learning experience that's like that.*

The two Galileo teachers brought their considerable teaching experience (Clifford & Friesen, 1993), knowledge of appropriate technology integration (Clifford & Friesen, 1998), and discipline expertise (i.e., one is a math, technology, science expert, and the other is a social sciences expert, and together they have taught kindergarten to university students) to bear on the development of a productive and collaborative relationship with each teacher. Together they were responsive to each teacher's level of technology skill and approaches to designing instruction, and worked with them, not on them, to develop inquiry-based projects for students (Clifford & Friesen, 2000).

Teacher Satisfaction

The administrators and teachers involved with this study expressed complete satisfaction with The Galileo Network's approach to onsite professional development and support. Teachers involved with Galileo Network in the 1999/2000 instructional year were very enthusiastic and confident about continuing to explore ways in which they could integrate technology and increase student engagement in their learning in subsequent years.

> *"To have Pat and Sharon in the classroom and listen to them listen to kids has been phenomenal for me. You don't go somewhere to be developed. Instead it's where you're at in your own teaching and learning. It's to be able to watch somebody else in action. I could explain to you what a chart looks like with 'learnings, frustrations and strategies' written at the top. I could show you how to set that up but it's really cool to see what happens as the kids are learning. And to have Pat in there to show you how to really listen to kids. And you're not talking about 'they're going to learn this today' you are allowing them to tell you what they are learning".*

> *"That constant presence and support within the building seems to have been really helpful in pushing the envelope. Teachers have been far more willing to really work at this."*

In short, teachers were overwhelmingly positive, felt renewed as professionals, and wanted to continue to work with The Galileo Network in the upcoming school year.

> *"Right now it feels like I'm living my PD. I'm doing what I need to do and applying it immediately."*

> *"... this has been the most challenging and exciting year that I've had because I've grown as an individual and can better reach all children and just the quality of the work that the kids have come up with, it's just incredible."*

> *"Teaching is such a lonely profession. You get in the classroom with those 32 kids and close the door and boom you have to make sense out of everything that happens without a lot of feedback except for when you're being evaluated. So Galileo is so non-threatening because it's what you need as a teacher... I think it's much stronger than any type of professional development I've ever been involved in and has so much more staying power than other approaches. With Galileo it's a growing process and I want to work with them on this kind of thing and I know it's only going to get better. I'm going to develop more skills and it's going to benefit my teaching and going to benefit my kids. It's an ongoing cascade of things that you can continue growing with. It certainly reflects the reality of how I learn."*

According to teachers, the professional development support provided by the Galileo Network is much less about technology integration, *per se*, and is instead focused more on inquiry into fundamental teaching and learning issues.

> *"It was never about the computers and the hardware. It was all about teaching and learning; the changes in your practice; the changes in your professional growth and how that can impact kids. Teachers became aware of the possibilities that were out there. How can we use technology to make learning meaningful and exciting? How can it be used to engage kids?"*

> *"Their [Pat and Sharon] priorities have to do with the instructional model. Their view very much is that in the way we look at learning, it's critical that technology supports that model and we use technology to make that model possible.... They encourage students to explore a topic, which will go on and develop a real depth to their understanding, not just researching a topic but seeing the patterns and the issues behind it that can be extracted from context... The technology simply allows and facilitates the student to do that in a variety of ways. Either by access to information that otherwise wouldn't be available, or by being able to communicate in a way which otherwise wouldn't be possible. So that's the heart of what they're doing. As we're implementing ICT, we're not just implementing the course of studies, we're also working with the schools to look at instructional processes and what constitutes part of their learning."*

In addition to feeling satisfied, and enjoying a sense of renewal about their professional careers, teachers believed that the changes to teaching and learning that they observed among their peers, and that they were now practicing, would be sustained in upcoming years.

"... Galileo was a true PD experience that I would never want to change and would fight to keep it in my teaching life. It was supportive, reflective, challenging, mind stretching, hard work, exciting, scary, the best experience that I have had to grow as a professional in my entire teaching career of 24 years. Galileo is PD that does not happen 8 times a year but instead it happens every day that I came to school. They made me think, reflect, challenge my practice, read and put into practice what I thought about but sometimes just did not 'get around to' because I was always too 'busy'".

"When a group of teachers will take time in June to discuss what they hope to accomplish in the following year at a time when most teachers are drained and discouraged and tired that tells me that there will be continuation the following year. Teachers mentioned the quality of their students work and the depth of the understanding that the kids had reached and some said they would not go back to the traditional teaching."

"I think my role as a teacher will progress while Galileo and these people are here to help us. I'm already thinking about next year and how I will do certain activities with the kids and how I'll incorporate the big question like Pat does. I'll have the kids make up the questions, not me. I'm not making the questions but I'll lead them there without too much talking."

Teachers commented on how the on-site and responsive professional development provided by the Galileo Network was more effective than a "one-size-fits-all" workshop model.

"It's different in that it definitely has interested me. It has helped me see that there's a way that is different and exciting. I see myself continuing on with this in the fall definitely. I definitely would like to do my professional development this way... Workshops really weren't that effective because you go and listen and everything and think 'okay yeah, I get it. It's a good idea' and go back to your classroom but you're just overwhelmed. Then you might find that it doesn't fit with your style of teaching. That is really different from Galileo's approach because when Sharon comes in I can see what she's doing. I can follow along and reflect and say what is she doing different than myself rather than being spoon-fed a bunch of information. So it's incredibly different and it's fabulous. And I'm hoping that she comes back next year too."

A teacher described how the relationship with Galileo Network was personally relevant and responsive to specific objectives and needs.

"I think the thing that appeals to me is it's so personal. It's not an approach that we're now in-serviced on to use and go on. We're taking our teaching style, we're adapting it and implementing new curriculum ideas, new teaching methodology, but it's all based on where we want to grow from and what we want to do."

Because the Galileo Network operates from a research-based foundation, they were also able to provide scholarly and intellectual mentorship to the staff of each school. The Galileo Network immersed itself in research related to learning theory and effective technology integration and was able to provide that perspective to teachers as they began to look critically at their own practice.

I really enjoyed the days when Galileo was in the school. They put some of the theory back into the teaching and I like it when theory and practice come together. I like the big picture and I don't think normally we take time to look at that when we're teaching. Usually we don't take time to put teaching into an academic type of context and you don't bother to reflect very much but Galileo helped to change that. I definitely did a lot more reflection about my practice this year and I probably wouldn't have bothered if we hadn't been working with Galileo.

... it puts knowledge as the goal rather than the product as the goal. The goal here is developing a deeper understanding. I think those are two huge strengths of the way Galileo does things. It demands. It demands justification, it demands questioning, it demands integrity because it pushes you to the wall and it asks "why, why, why?" "How, how, how?" not "what, where and when?" It poses the questions. It makes you ask the questions, it makes students ask the questions of themselves, it puts responsibility in the hearts of every single person involved.

Section III - Engaged Student Learning

Interviews with teachers, students, administrators and members of the Galileo Educational Network facilitated the development of a shared understanding and language from which to articulate the impact of professional development initiatives on student learning in the school. A conceptual framework for understanding the relationship between effective learning and technology is provided by the North Central Regional Educational Laboratory's (1995) New Times Demand New Ways Of Learning document, and the North Central Regional Technology in Education Consortium's (2000) Learning With Technology Profile Tool. The framework for measuring *engaged student learning* is presented as 26 indicators that are organized into 8 categories of learning and instruction: (1) vision of learning, (2) tasks, (3) assessment, (4) instruction, (5) learning context, (6) grouping, (7) teacher roles, and (8) student roles.

The following section presents selected instances and examples of engaged student learning using the NCREL framework. Information is taken from interviews with the teachers and students who worked with The Galileo Network. The following section illustrates how projects and tasks that are designed for students are authentic, challenging, and multidisciplinary.

Authentic - Student learning tasks bear a close relationship to real world problems in the home and workplaces of today and tomorrow, build on life experiences, require in-depth work, benefit from frequent collaboration, and are of relevance and interest to learner(s) (NCREL, 1995, 2000).

"These are huge learnings for these kids that are significant, meaningful and important. I now have kids who are ready to crusade to join Ducks Unlimited and who really believe they can change the world. I don't want to lose that enthusiasm because education and society needs that passion. I see an excitement in these kids as they do their projects. I see and excitement for learning rather than a tedious regurgitation of what either they had to read or what their teacher has taught them. Now I'm finding that they're taking the information and they are

applying it at a higher level and even my kids that are struggling are having success with it. They might need some more support through it but they certainly seem committed to doing the work".

Challenging - Student learning tasks are complex and typically involve sustained amounts of time. Students must stretch their thinking and social skills in order to be successful (NCREL, 1995, 2000).

"Well, initially... I was skeptical... I wasn't sure if kids would be able to grasp this information. Dead wrong... They're just sponges. I don't think, you know I look now at what I used to do... and it's just gone tenfold in what these kids can handle. The challenges we throw at them, they surprise me all the time. The things they can handle. I mean, even the things we're doing right now near the end of the year, you know, it just surprises me some of the concepts they can grasp. Not all of them but I would say a good portion of the class. I think a lot of it has to do with the fact that we're just giving them the freedom. We're not saying, okay this is what we're doing and this is a lock-step program and we're not going to go beyond these boundaries, not going to challenge your little brains at all, and as soon as we say that, I think we put these limits on these kids, but we're not doing that. We're allowing them to explore, allowing them to push themselves".

"What's interesting is that my top kids hare having more difficulty with it than my average kids or kids with lower abilities. Because the top kids have always done reports in the past and they've received A's for them they think they know how to do it all without really stopping to think. Whereas the average kid tends to have to think more and so this way of thinking isn't as far of a stretch for them. On the other hand the top kids are saying 'I did it this way last year and I got an A so why can't I just do the same thing this year?' So they are having a harder time with it. I truly think we're pushing these kids farther than they have ever gone before. For most of them it has been really exciting and definitely worth it".

Multidisciplinary - Disciplines are wholly integrated in order to solve problems or address issues (NCREL, 1995, 2000). Instead of tasks being conceptualized as content bits, or parts of a whole, the impetus for designing learning environments becomes an emphasis on enduring ideas that excite scientists, researchers and the great thinkers of our time.

"This way of working takes a lot longer though for instance my Canada unit went for half a year and I was just panicking because I was thinking that I've got so much more to cover. But when I look at what the kids have learned in that half a year, it took longer but it was well worth it. I think we have covered more objectives this way than we would have if I would have panicked and stopped to 'cover' Quebec and Canada and then Alberta and becoming obsessed with the time restrictions".

Teachers More Important Than Ever

Those who work with computers for learning know that the practical wisdom of teacher cannot be replaced by a machine. Practical wisdom refers to a teacher's ability to draw upon conceptual knowledge about disciplines and constructs under study (i.e., numeracy, literacy, citizenship, culture, biology, and such), and pedagogical knowledge (both theoretical and practical), when making daily decisions, planning courses of study, and making judgements about learners, teaching, and schooling. It is not enough to know "how" to teach; one also needs to negotiate the tension surrounding "why" we teach, and "what" we teach, as it relates to societies' values, hopes and ambitions for children. A fundamental question to ask about all that we do in education is "what is worth knowing?" It is a loaded question; one full of moral and legal implications. What is perceived as "the right thing to study" versus "the wrong thing", and who decides? What is the legacy that we want to pass on to this generation of children? What do we want them to know about themselves? What do we want them to know and understand about the world in which they live? What does the world know about itself? What is truth, and what is not?

Reflective teachers wrestle with theoretical understandings, described well by Dewey's (1933) argument about reflection as "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends", and also the practical implications of "what we know and how we know it" and how this knowledge can be translated into designing learning environments for children, and making decisions on their behalf. Decisions about how technology is integrated into instruction require active, thoughtful, and deeply moral consideration and reflection by teachers who are actively and deeply engaged with their discipline.

The myth that computers will replace teachers comes from the old computer-assisted-instruction, content driven applications paradigm that builds upon the transfer and delivery model of education. The saying that teachers are "no longer the sage on the stage, but the guide on the side", has become somewhat standard fare in conversations about technology integration. But, what does this really mean? What was clear from this investigation was that the teacher's role did change. Instead of being a dispenser and controller of information, using a "stand and deliver" lecture format based on information transfer, the teacher became more of a facilitator, guide and co-learner & co-investigator. As a facilitator, teachers created opportunities for students to work collaboratively to solve problems, do authentic tasks, and share knowledge and responsibility (NCREL, 1995, 2000). Teachers described how they focused on mini-lessons versus whole class instruction once a project was underway. Students were trusted to work where they needed to be for optimal learning and or access to resources (i.e., in the library, on computers, in the classroom), instead of all children being under the direct gaze of their teacher all of the time. Tasks were designed to be authentic and engaging, and built on student's interests, ideas and active questioning, rather than dispensed as photocopied sets of preset questions for students to fill in. Assessment rubrics and performance indicators were designed to reflect the students' active engagement with problems and questions, and demonstration of new understandings to a wider audience, rather than predetermined answer keys where there is only one way to be right.

As guide, teachers helped students construct their own meaning by modeling, mediating, coaching, and constantly adjusting the level of information and support according to individual student's needs (NCREL, 1995, 2000). In one teacher's words, *"when [students] ask the questions you are delivering "just in time" learning. It's learning when it's required rather than learning how to do a spreadsheet just in case you need to know how to do that eight months down the road. Students are acquiring the technological skills and knowledge as they need it within the context of their work".* Inquiry projects were designed to give students an opportunity to explore essential questions and spend sustained time with the enduring ideas of a discipline. Instead of rushing from this activity to that activity every time the bell rings, students were given long periods of time to meet and work in groups, discuss alternative approaches to problem solving, seek out resources, organize their approach to representing and presenting their findings, and prepare presentations.

Teachers focused on uncovering the curriculum versus curriculum coverage. Because the goal was to get students involved in researching big ideas and essential questions (Clifford & Friesen, 2000; McKenzie, 1997), teachers were supported in their investigation and analysis of the curriculum. Teachers were encouraged to engage deeply with the curriculum, and design projects that went well beyond fact finding. Instead of deciding, on behalf of the students, how to chop the curriculum into easily digestible bits, and then delivering it to them, the teachers negotiated with students to determine what important questions in the discipline were and how they might investigate them together, as a learning community.

It is useful, at this point, to revisit the question of how inquiry fits in the larger context of "coming to know oneself" and "coming to know about the world" as a teacher and learner. The inquiry task is an iterative and disciplined cycle of research, reflection, writing, and revising one's knowledge and understanding of a phenomena under study. It is not an exercise in "knowing all", but an intellectual pursuit of "knowing more than before". Unlike a fact-based form of research, the iterative cycle of inquiry is not "done" when the project, or product, or paper, is finally presented to the group. The "product" represents, necessarily, only a partial explanation of the phenomena under study. Constraints, such as research time, access to primary and secondary resources, writing skill, research ability, motivation, and so on will affect the quality of the argument or explanation about the phenomena that is offered by the knower. As Palmer (1998) argues in Chapter 4, "the community of truth, far from being linear and static and hierarchical, is circular, interactive, and dynamic" (p. 103). It is impossible to "know all" about a subject or topic. There is always more to know because the subject itself keeps changing, and as Palmer (1998) reflects, "the subject knows itself better than we can ever know it, and it forever evades our grasp by keeping its own secrets" (p. 105). The Galileo teachers supported teachers in their own approach to inquiry-based research and instructional design so that they could experience first hand the learning opportunities they were called upon to provide for children.

Debra Meier (1995) describes the importance of inviting children into an authentic relationship with research and inquiry so that "all children could and should be inventors of their own theories, critics of other people's ideas, analyzers of evidence, and makers of their own personal marks on this most complex world" (p. 4). Along with their students, teachers were co-learners who were also involved in the iterative cycle of "knowing more than before", and not necessarily knowing all about a discipline or topic. Galileo teachers supported teachers in their own re-discovery and reconsideration of the fundamental ideas in a discipline. Giving up the label of expert, and joining students as a co-learner, co-investigator, was quite liberating and felt more authentic for most of the teachers involved with the Galileo initiative; many reflected upon how giving up the traditional role of "teacher-as-expert" can be quite threatening, and almost impossible to fathom, for some of their colleagues.

Teachers interviewed in this study tended to design inquiry projects for their students in which the desired learning outcomes were the construction of new knowledge and understandings, rather than merely summarizing what was already known about a topic. Teachers provided a structured set of expectations, resources and standards, and also provided ample space in which students could ask and pursue their own questions and ideas. One teacher described that "*Teachers are still setting the stage in the beginning and doing the prospecting with the kids but the learning has gone beyond just prospecting. Before learning stopped at the report stage or at the power point presentation but now they are investigating issues so it is going beyond. Teachers and students are looking at issues in the real world differently*". Instead of one way to be correct, or a single way to achieve the learning objectives, students had hundreds of ways to demonstrate their understanding of a topic. In many ways, teachers and students were co-learners, especially with some of the new ways of representing knowledge, and making optimal use of the technology. *"The students tended to take the projects as far as they could which were farther than if I had directed all of it. It is changed in that I have given up some of the direction and I have been more of a mentor and a helper then I have really been the one teaching them. They've been learning as they've been going and from each other... "*

One teacher described her role as building an environment that supports collaborative knowledge building. *"And so my role then is to walk around and just to listen in and to probe and to ask something maybe that brings discussion to another level, ask a question. So they look to each other now for answers, they don't always look to me, and I guess that might be the biggest difference between the way those kids that walked into the room in September, and leaving now, they know that knowledge comes from all over. It's not just from the one who is tallest".* Instead of always looking to the teacher for direction or advice, students were encouraged to build on each other's strengths, to pursue shared goals, and to contribute their diverse knowledge to the group's outcome. Teachers and students worked together in engaged ways, and they all become valued members of the learning community. Each had a role in contributing their own discoveries and ideas to the collective whole and making their own thinking processes more explicit at the same time.

> *"Therefore the research moves beyond mere reporting of the physical description of the animal into more interesting connections with the region and broader environmental issues. I think the kids are thinking at a higher level than if they're just regurgitating research and because they've had to make those kinds of connections some of the work is really outstanding...the research is so much more exciting because the students have to think about the research itself and how it connects to bigger issues...This was not information that students would find in a book. Instead they were required to think about and connect different bits of information into a meaningful whole."*

Teachers described ways in which they coached students, and engaged them in a cognitive apprenticeship. *"You let them become the experts. They are telling you what they know and what they know is quite amazing. That's what's happening. And that's been a lesson for me. I think I* *always knew that they knew a lot but there was that certain point where I would say 'okay now that we brainstormed let's move on'. And now I think I would spend more time with them going 'oh that's interesting'. Asking them where they learned that and how they know that. Let them really spell it out too and elaborate on it. Let them be the experts".* Learning is situated in relationship with mentor who coaches students to develop ideas and skills that simulate the role of practicing professionals (i.e., engage in real research) by observing, applying, and refining ideas through practicing the thinking processes used by practitioners in specific content areas (NCREL, 1995, 2000).

If I Teach In These New Ways, I Am Doing My Job

A narrative account of visits to one teacher's classroom is presented to illustrate some of the ideas presented in Sprague and Dede's (1999) description of constructivist approaches to teaching with computers. Sprague and Dede (1999) present the principal's reaction to two teaching scenarios, one of a teacher who uses an inquiry-based approach to infusing technology in the classroom, and one of a teacher who does not. At first, the principal is more comfortable with the recognizable order in the traditional teacher's classroom; students are in rows, teacher is lecturing, computers are absent. The principal's views about what effective practice looks like change, however, when presented with evidence of more engaged learning in the first teacher's classroom via parent feedback.

In the course of the present investigation, the researcher visited Anne's grade two classroom several times to meet with her and speak with students. On one such visit, I observed that her grade two students were distributed throughout the pod using computers in other classrooms. A pod is an arrangement of four classrooms that share a hallway radiating from the center of the school. I observed students working on their electronic portfolios that they had been constructing since the beginning of the year. One student described for me what each slide in her portfolio was about, and as she navigated the slides which recorded her reflections about math, reading, story writing, and symmetry, I was amazed by the amount of learning that the child's portfolio represented.

As I spoke with more of the grade two students, it became clear that each had benefited from the opportunity to build an ongoing account of their learning throughout the year. The electronic portfolios contained a diverse range of writing samples, digital photographs of the student painting or working in a group, different questions they had been working on in social studies, scanned drawings, concepts they had been thinking about in mathematics, the levels of reading they had achieved and examples of books they had read, and so on. The students themselves were able to speak at length about each of the slides they had created. Anne had set up the classroom structure in such a way that each time the class completed a project or investigation, she led a discussion with the class and prompted them to create a new slide to capture their learning at that point in time. What appeared to be particularly valuable about this approach was that every child had the opportunity to reflect upon and think about their learning individually, and write down or capture thoughts about what was most memorable and meaningful to them at the time. Anne opened a space for the students to work on their portfolios throughout the year, and made time available in class for individual students to work on this task, or as a whole group when they had access to the computer lab. Students were able to articulate the meaning and significance of each slide, and relate the visual representation to the learning that had occurred.

What emerged as particularly notable about this visit was how the grade two teacher organized and managed the class. Anne walked around to the different classrooms in the pod because the children were distributed; some children worked at computers in other classrooms, some worked on the two computers in their own classroom. This all happened while the other classes were in session. The children used the computers to work on their portfolios or to work on other projects. It was fascinating how Anne had negotiated this teaching arrangement with her students and the other teachers. There was no discomfort about students being on their own, or whether students were on task; Anne trusted her students to be working on their portfolios even though they weren't under her watchful eye every minute.

The students worked energetically and productively on their electronic portfolios, and were helpful and articulate in explaining the nature of their work to me. Although this arrangement was very productive and seamless for the students, the teacher was almost apologetic about it with me. Initially concerned about my reaction, she said, *"I'm sorry, it probably didn't seem like a class to you but a class is going on. The students are all over the place, but they are working on their portfolios"*. It occurred to me that as teachers risk the changes that accompany working in constructivist ways with children and technology, it is difficult not to feel self-conscious. Teachers know that is risky for their classroom to look different. There is a tension that accompanies changed teacher roles; there is a traditional and strongly held view of what good teaching "looks like"; children working quietly in desks in orderly rows. Management and control. Aware of how the classroom arrangement might be viewed by an outsider, Anne felt a need to defend her way of working with children. Sprague and Dede (1999) capture this reaction to "difference" effectively in the principal who is initially skeptical about whether learning can occur in environments where the teacher is not directing and orchestrating from the front of the room while children sit attentively (or not) in their desks.

There is also the reaction to having a researcher present who has asked your permission to observe and take notes. Being watched is also a risky prospect. Teachers know how to show things that people want to see; well managed, obedient children who pay attention to the teacher's performance. How do they know who they can trust to show the things that they see and believe in? In this case, Anne extended a tentative invitation to me; an invitation to see the value in what the children were doing with their portfolios.

I began to wonder about how Anne might organize her classroom if she had ubiquitous access to more computers near or in her classroom. She could have a group of students working on the computers whenever they needed to and there would be no need to troop the lot of them up to a lab. This teacher has sporadic access to eight computers distributed in the pod, and she's making full use of them. Imagine the types of learning opportunities that Anne could arrange for her students if they had more access to computers. It is sobering to think about the constraints this teacher and her students face with access to only one or two computers in her classroom that she can count on all of the time, six more in other classrooms, and a full set if she is willing to troop her kids up to the lab. The computer lab in this school is fully booked every day of the week. The lab is hopping with children and teachers all day long. One class is walking out as another class is walking in. A phenomena that characterizes almost all of the classes is that the children know exactly what they're supposed to be doing. So the students log in, they get to work right away, and they turn to each other for help. The students and teachers in this school are making good use of the time in the lab.

Overall Research Findings From Three Schools

During the 1999/2000 instructional year, the Galileo Educational Network provided extensive professional development support to administrators and teachers at three different elementary schools. It is clear from an analysis of observations and information from teachers and students in the three schools that:

(a) when presented with opportunities to explore and inquire into essential questions and enduring ideas that are meaningful to them, students' work exceeds expectations for level and quality of scholarship in elementary school; student engagement when working in these new ways was sustained, and at higher levels of thinking and reasoning;

(b) students were introduced to new ways of using technology for their work using "just-in-time" not "just-in-case" approaches to instruction both in schools with labs (scheduled access) and with distributed networks and workstations (anytime access); rarely was instruction focused on the technology itself, instead instruction focused on the research or construction tasks, and how technology might best serve the task;

(c) teachers implemented both fundamentally different teaching and learning strategies, and also integrated new technologies (for them), with the support of the Galileo Network teachers; many teachers admitted that they would not have pushed themselves and their students as far without the onsite access to sustained professional dialogue, pedagogical and technological support, collegiality, and reassurance of the Galileo Network teachers.

One explanation for the teacher's overwhelming support of and satisfaction with the professional development support they received can be found in the description of the innovation-decision process; an individual's decision to adopt an innovation is rarely an instantaneous act. An innovation decision is a process that occurs over time, and consists of a series of actions, influences and decisions (Rogers, 1995). Teachers appeared to be influenced in their decision to adopt technology by the perceived benefits and value for students. Through professional dialogue with colleagues and the Galileo teachers, and by exposure to the results that other teachers had achieved with students, teachers became more convinced of the relative advantage offered by innovative practice and ICT integration. To learn about and be convinced of the value of innovative educational practices and ICT integration is only part of the innovation decision process (i.e., knowledge and persuasion). Teachers were supported in their decision making, instructional planning and classroom implementation of inquiry-based projects with students by Galileo teachers (i.e., decision and implementation). It was not enough that teachers in these three schools had access to technology. In two of the three schools, teachers and students had average to above average access to computers and networking. Teachers were willing to risk uncertainty, plan for changed roles, and develop their own technology and pedagogical skills, with the support from the Galileo Network. Teachers were also supported in their assessment and evaluation of student products and achievements as a result of the new approaches to designing instruction (i.e., confirmation).

Overall, teachers appeared to be influenced in their adoption and implementation decisions by the larger social, cultural and political contexts that frame what and how they teach in classrooms. The Galileo Educational Network formed a relationship with school district personnel, school administration, school teachers, students, and parents. The Galileo Network worked with people at all levels of the educational organization in order to help build a culture that supports and expects reformed ways of teaching and learning with ICT. A social and political culture of reform and innovation, and expectation that people would be charting new territory, helped to support teachers in making changes to their practice. An integral component of the culture of "expectation" in each of these schools was the support for change provided by regular access to onsite support and expertise, and the time to make optimal use of the onsite professional development. Debra Meier (1995) on professional development:

> "Thoughtfulness is time-consuming. Collaboration is time-consuming. The time they both consume can't all be private time, late-at-night at-home time. To find time for thoughtful discussion we need to create schools in which consensus is easy to arrive at while argument is encouraged (even fostered) and focused on those issues of teaching and learning close to teacher and student experiences… (p. 108)"
>
> "This continuing dialogue, face to face, over and over, is a powerful educative force. It is our primary form of staff development (p. 109)".

Teachers were not expected to stay after school, or come in for seminars and workshops on weekends, to be professionally developed. Teachers were given time during the school day to access expertise and resources, to plan projects, and were supported in their efforts to implement changed practices and methods, and evaluate the result. The GENA initiative was most successful this first year in schools in which all (or most) of the teachers had an active involvement or stake in the project, and it was an overall part of the school improvement plan. Thus, in some schools, the Galileo teachers had input on the technology committee, they had input on the professional development committee, had discussions with whole staffs, and worked with ICT support staff at the district level. The initiative tended to be somewhat less successful when the contact with teachers and teacher involvement was disconnected, sporadic, and limited.

Educational Importance Of The Study

This study contributes to knowledge in four broad ways. Outcomes of the present investigation, some of which are reported upon in this paper, are: (1) descriptions of individual, group and organizational adoption patterns of technology for teaching and learning across disciplines in three elementary schools, (2) case histories of adoption decisions and experiences of individual teachers, (3) images of exemplary practice for teaching, learning and research, and (4) evidence linking technology integration and engaged learning.

This investigation has theoretical and practical significance. *First*, this investigation increases understanding of the diffusion of innovations, and the application of the theory and conceptual models in education. Results are of practical interest to schools as they face the challenge of encouraging widespread adoption of technology for teaching and learning to implement the Technology Outcomes curricula across subject areas.

Second, a systematic documentation of adoption patterns and characteristics of administrators and teachers who have integrated technology with the support of the Galileo Educational Network in three Calgary area schools provides practical and generalizable information about the organizational affordances and constraints to do with technology integration. Most importantly, results from the use of a shared instrument to assess where students and staff members are at, both at on the scales of engaged learning and stages of technology adoption, can form the foundation for the next steps in the planning and implementation process at each school. This information is also useful to different groups in education: (1) decision makers in leadership positions, such as ministers of education, superintendents, and school administrators, (2) administrators, teachers and researchers interested in integrating technology for teaching and learning in schools, both personally and at the school-wide level, and (3) researchers in broader areas: teacher preparation, higher education, leadership, organizational change, educational technology, and administration.

Third, the dissemination of best practices in teaching and learning provides much-needed images of how technology *can* be used efficaciously in education for meaningful student learning outcomes. Knowledge of this kind will be useful at the organizational and individual level for professional development for technology integration, and for further research in the area.

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