Developing a Technology Integration Capability Maturity Model for K-12 Schools

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Abstract

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A Capability Maturity Model (CMM) is a five-level hierarchical model used to improve organizational processes by assessing and categorizing practices within a defined and standardized framework, and by providing methods for making a sequential transition to the next level. CMM's including the software CMM (SW-CMM) and the People CMM are used by the software industry and human resources departments to evaluate organizational function and provide a guideline for improvement. This multi-case study of six K-12 schools uses interviews and questionnaires to define a Technology Integration Capability Maturity Model in the context of classroom projects and technology activities. Computers and related technologies in schools are relatively new compared to traditional teaching practices. Many teachers and administrators try to use this technology to enhance their practice and perhaps examine their existing pedagogy. The TI-CMM has been built based on experiences of schools at various stages of technology use. The collected data were analyzed to determine the Key Process Areas and practices that define the five levels. The result is a model that can be used to assist not only in technology planning, but in designing pedagogically effective technology activities. Each level of the TI-CMM is defined by several Key Process areas which are further defined by goals representing concrete actions that can be taken by teachers and administrators. Successful attainment of these goals will assist schools in using technology to enhance its pedagogical effectiveness.

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Chapter 1

Introduction

Just as computers and the Internet[1] have pervaded the workplace and homes in our society, they are becoming increasingly commonplace in K-12 schools. Government support in the form of legislation and financial subsidies in both Canada and the United States has ensured that access to technology [2]and the Internet in schools will increase (Angus-Reid, 2000). The United States has established a Technology Literary Challenge Fund, which has allocated over $400 million in 1998 to fund technology in all states to encourage the integration of technology into teaching and learning (Resource Guide to Federal Funding for Technology in Education, 1998). In Canada, government policy aims to have all educational institutions connected to the Internet, if they aren't already (Advisory Committee for Online Learning, 2001). Large sums of money have been spent equipping schools with computers, wiring for network access and paying Internet Service Providers. These are ongoing expenses, as schools then require faster computers, faster Internet access in more locations in the school, and software upgrades. Education, which was once strictly labor-intensive, has become a capital-intensive endeavor as well.

Planning to implement technology for effective teaching and learning is a challenge especially given the rapidly changing pace of technology, making technology planning a responsive and recurring endeavour. Evaluating the outcomes of these capital investments and the impact of technology on education is a complex and nebulous task.

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[1] While the World Wide Web (in the form of html and http protocols) is the best-known aspect of the Internet, there are many other protocols in use, supporting applications such as electronic mail, Usenet, chat, remote login and ftp or file transfer protocol (http://www.w3.org/ World Wide Web Consortium). Throughout this paper, the term Internet will be used to represent all of these networked communications protocols.

[2] Although the term technology can apply to many devices, electronic and otherwise, in this paper, the term will be used to refer to computers and the Internet.

Still, some degree of accountability by schools is necessary and valued by parents, students, and the public. While schools are not businesses, in that they have fundamentally different values and purposes (education vs. profit), schools are organizations with people, management, clients, processes, and outcomes to manage and improve. Successful models used in the corporate world can be adapted if they are modified to reflect the goals of elementary, middle and high school environments. Technology planning can be characterized as non-standard procedure and often even improvised as funds or new equipment become available. Some common approaches to technology planning and evaluation will be discussed in the Literature Review.

Capability Maturity Models

A Capability Maturity Model is a tool for process implementation and improvement that has been used in software engineering and organizational management for two decades (Sommerville, 2001). A CMM is a five-level hierarchical model used to improve organizational processes by assessing and categorizing practices within a defined and standardized framework. Each level of this framework includes appraisal mechanisms and methods for making a sequential transition to the next level. It is also an evaluation tool, often used for self-evaluation according to an acknowledged and accepted standard that has been proven effective for similar organizations.

A study by the U.S. Software Engineering Institute determined that as organizations reach higher levels of a CMM and implement the initiatives defined by the Key Process Areas (KPA) of each level, the organization does benefit in terms of a higher quality product, higher productivity, fewer product faults, faster time to market, and

higher return on investment. The amount of improvement varied depending on the type of organization and the version of the CMM they were using (Pfleeger, 1998).

The five levels of a CMM and their basic characteristics are: (Carnegie Mellon Software Engineering Institute, 2002)

Level 1 Initial	This level is characterized by ad-hoc, possibly chaotic activity. Project success often depends on individuals; accordingly, the organization is dependent on individuals and hiring outstanding employees.
Level 2 Repeatable	At this level, basic management processes are established along with some documentation (e.g. costs, schedules). Consequently, it is possible to repeat previous successes.
Level 3 Defined	At this stage, all processes are documented and standardized. Projects use approved version of organization's standards, ensuring an even higher ratio of project success.
Level 4 Managed	Called a quantitative level, detailed measures of processes and product quality are collected. These data are used to establish controls to ensure quality & performance.
Level 5 Optimized	This has been called a qualitative level. Innovative projects are encouraged and piloted. Feedback from processes allows for continuous innovation.

The original Software CMM has been adapted for use in other domains, including the P-CMM (for people and human resource practices), SE-CMM for Systems Engineering to name only two.

Each maturity level has Key Process Areas (KPA), which in turn are comprised of goals and practices (Curtis, Hefley, & Miller, 2002). Key process areas are related and describe the functions on which an organization should focus as part of its improvement activities, and they vary depending on the domain of application (Pfleeger, 1998). At the initial level there are no Key Process Areas. Each KPA is further defined by

several goals, which in turn are defined by practices that contribute to achieving these goals. These are often called "best practices".

Purpose

The purpose of this research is to develop a Technology Integration Capability Maturity Model (TI-CMM) for K-12 schools by answering these research questions:

For each level of the TI-CMM:

a) What are the Key Process Areas that would define a Technology Integration Capability Maturity Model for K-12 schools?

b) What goals would define the identified KPA's?

c) What are examples of best practices that support these goals?

In essence, the research describes the characteristics of each level of the TI-CMM in an educational setting, specifically in the context of technology planning and use by teachers.

Data regarding the technology planning process, availability of equipment, network infrastructure, teachers' attitudes and skill levels, and examples of technology use have been gathered and analyzed within the framework of the generic CMM framework to develop descriptions for the KPA's, goals, and best practices at each level of the TI-CMM. A central premise of this model is that the purpose of technology in schools is to support teaching and improve or somehow enhance the learning process.

This research is important for several reasons. As more schools add computer and Internet resources, it is important that administrators and technology coordinators have plans for implementing and improving the use of technology within their school. The research examines the extent to which technology plans affect the amount and quality of technology integration in the classroom. The model also can serve as an evaluation tool to assess the current use of technology, and then, if desired, determine a direction or action to move to the next maturity level. Departments and individual teachers can use the model for goals of technology integration and examples of best practices. Teacher trainers can use the TI-CMM in designing professional development activities. Because this model is "grounded" in the data, the model and the data collected will be of interest to K-12 school administrators and teachers as examples of concerns and activities taken from actual schools, not as "theorized" best practice. Finally, educational researchers may extend the model, as the proposed TI-CMM is an open framework; additional processes and key process areas can be added to improve practice.

Literature Review

Technology Planning

Supporters of computers and related technologies in schools claim that these technologies will increase communication between students and teachers, provide access to resources that may otherwise not be available in the classroom, and encourage "authentic" learning as students access "real-world" data not provided by textbooks (Schrum, 1995). The use of technology can also provide a catalyst for teachers to examine their practice, perhaps moving from a didactic to constructivist practice (Becker & Ravitz, 1999; Dexter, Anderson, & Becker, 1999).

There is consensus that funding hardware and connectivity are not sufficient to make this investment worthwhile – adequate training must be provided for teachers (Hasselbring, Barron, & Risko, 2000). Much of this training is done on an impromptu or informal basis by district or school technology coordinators, focusing on only computer skills and not how to use the technology in the classroom. (Milken, 1998).

Technology planning models generally fall into one of three categories: top-down, bottom-up, or mixed. Top down approaches are mandated by a government body or school board. This model often ensures adequate funding, but since schools are required to adopt an innovation, there may be a tendency to do so superficially or possibly engender greater reluctance by teachers to use the new technology. That is, the school might acquire the technology without incorporating other features to ensure the educational goals of integration are met.

A bottom up approach is site-based where the technology initiative is teacher driven. Consequently, this model has an important advantage as teachers are better placed

to understand and implement an innovation that they themselves adopt. The time to get to the "substance" of the classroom innovation is shorter. In the process of implementing new technologies in teaching, teachers are the primary change agents, and they influence, to a large extent, how technologies are finally used in the classroom (Hooper & Rieber, 1995). Fuller's (2000) examination of technology support for teachers suggests that teacher acceptance is a critical factor in the successful use of computers in the classroom. The difficulty with this model is that funding is usually determined at a macro-level (ie administrative or school board level) and resources may not be equitably distributed, hence this is not a systemic approach.

A mixed initiative is a combination of the two previous models creating a hybrid model of reform that combines the advantages of the top-down and bottom up approaches, where the governing body provides funds and resources, yet recognizes the importance of local acceptance. The structure is determined by the top-down approach, but the details are worked out at the classroom or school level. The State of Indiana presents an example of this type of planning. The State dictates the general guidelines for the technology plan, but leaves the details to each school (Indiana Department of Education, 2002), as does the California Master Plan for Educational Technology, which lists nine recommendations for schools including acquisition of resources, equitable distribution, professional development, and evaluation of the plan (California Department of Education, 1992).

In a separate category from technology planning are innovation models that attempt to explain how people accept and adopt innovations. These models do not specifically address professional development, budgeting, acquisition, distribution, or

infrastructure. They are valuable as they may provide a better understanding of how the innovation is being accepted and used at the classroom level.

One of the more frequently referenced innovation models is Rogers' Diffusion Theory (Rogers, 1995). This theory was developed to explain how any innovation, defined as new process or object, affects a social system and how quickly it is accepted by the members of the system. While applicable in any domain, it is often referenced when discussing computer and Internet acceptance and use in schools. The four components of the theory include the innovation, the social system, the communication channels within the social system, and time. According to this theory, the diffusion process has five steps: *knowledge* – becoming aware of the innovation, *persuasion* – becoming convinced that the innovation has value, *decision* – deciding to use it, *implementation* – using the innovation, and *confirmation* – confirmation of the decision based on positive results from using the innovation. So the first step is learning about an innovation, and then trying it out before making a decision to adopt or reject it. In this model, the decision to use a new resource is actually a process, and initial use does not ensure further acceptance. The rate at which an innovation is adopted is affected by whether or not the potential adopters perceive it to be compatible with their existing values, whether they can try it out or practice with it and it is easy to use (or at least not overly complex), and whether it offers visible, positive results.

Rogers notes that in a given population, not everyone will accept the innovation, and he has created labels to describe the different levels of acceptance. "Innovators" take an early lead, "Early Adopters" adopt the innovation and are usually the role models for others, the "Early Majority" watch to see the successes of the Early Adopters before

attempting to use an innovation, the "Late Majority" tend to accept the innovation after feeling some pressure to do so from others, and "Laggards" resist as long as possible as they are suspicious of change, feeling that what works in the past will continue to work without alterations.

Rogers' theory is comprehensive as he has defined attributes of an innovation that help adopters determine whether to use it. New technology is more likely to be adopted if it is perceived to be something that is compatible with one's personal and professional goals, not too complex, provides some "added value" or is an improvement over a current method of doing something. He also proposes a timeline of innovation that has early adoption at a very slow pace, followed by a sharp increase in acceptance, which then levels off. This model is important to help understand how teachers may decide whether or not to use technology.

Another model of technology innovation that is often referenced is the Concerns-Based Adoption Model or CBAM (Hall, Loucks, Rutherford & Newlove, 1975). There are three dimensions of the CBAM: the stages of concern (SoC), level of use (LoU), and innovation configuration (IC). The SoC and LoU dimensions have been well validated through research in the last decade (Hall, George & Rutherford, 1985; Griffin & Christensen, 1999), although there has been less interest in the IC component. The Stages of Concern describe how teachers perceive an innovation and their feelings about it by selecting a number on a scale ranging from a low of 0 to a high of 6. The Level of Use instrument identifies the extent to which teachers are using an innovation, again on a scale from 0 to 6. This instrument is explained in detail in the Research Method Section.

Newhouse (2001) used all components of the CBAM in the evaluation of a laptop programme. He concluded that it is a useful model and encouraged other researchers to consider its use. In particular, he found it valuable for developing an understanding of teachers' use of an innovation and then to assist in developing professional development activities more tailored to the characteristics of the innovation.

Hooper & Rieber (1995) propose another intriguing and similar hierarchical model of technology adoption, which starts with a Familiarization phase, where teachers are initially exposed to a new idea. The second phase, Utilization, occurs when the teacher tries the technology in the classroom. The third phase is Integration where the teacher consciously decides to do certain tasks with technology. If it is removed, the educator cannot proceed with his/her lesson as planned. In the fourth stage, Reorientation, the teacher re-evaluates his/her role in the classroom from being a source of information to developing a learning environment where the learner becomes "the subject rather than the object of education." (Hooper & Rieber, 1995, p. 159). In the last phase, Reorientation, teachers include technology in the classroom without having to be experts themselves - they are concerned with how technology allows students to engage more effectively with the subject matter. Becker & Ravitz (1999) performed an exploratory study where they discovered that, in their sample, use of computers and the Internet is more consistently related to constructivist teaching practices.

Both Hooper & Rieber's model and the CBAM focus almost entirely on the teacher's acceptance and use of an innovation, which is the major component of effective use of technology.

Cuban, Kirkpatrick, and Peck (2001) suggest that the structure of schools with daily subject specific classes limited to a time period, where teachers are required to adhere to a mandated curriculum of transferring knowledge to students does not provide the best environment for technology integration. They suggest another reason for this paradox is the "slow revolution" explanation, where small changes accumulating over time create a slow transformation. It may be that by assigning teachers their own laptop computers, the small changes accumulate faster, increasing teacher readiness for use in their classes. I would also put forth the common argument that teachers are not as comfortable with computers as their students, and therefore they resist using computers in front of or with their students so they don't appear deficient or lose their position of intellectual authority. Once again, providing them with their own computer helps to ease this perception. There is no lack of research on factors that contribute to teachers' use of technology. Increased access to resources affects teachers' confidence in their ability to use technology well, and this confidence increased as they gained more experience using technology in the classroom (Ross, Hogaboam-Gray, Hannay, 1999).

Many published papers have examined and evaluated individual technology projects in schools, but there are fewer similar evaluations of entire technology plans. Laptop programmes or one-to-one laptop computing models have been more comprehensively evaluated, probably because of the novelty of this initiative and the financial expenditure required by parents and schools. In these programmes, students and teachers acquire their own notebook or laptop computer for use in school and at home. Evaluation is often done by a third party using instructor-developed questionnaires targeting students' and teachers' attitudes toward the project, and how they have used the

computers in their teaching and learning. The reports also consider student learning outcomes such as scores on standardized writing and mathematics tests, and subject grades in comparison to non-laptop students. (Rockman, 1997, 1998, 2000; Stevenson, 1999; Hill et. al., 2000, 2001). These reports are comprehensive, but they report results without reference to goals from the original technology plan. Recommendations for improvement are generic and apply specifically to the laptop model. A case study of three laptop universities examined models of laptop programme implementation and proposed a modified model for this process within higher-education (Ives, 2002). Ives (2002) makes note of the complex environmental and political forces imposed on educational institutions trying to adopt technology and that a participative model of planning is necessary.

Need for evaluation of technology plans and accountability

Many of these plans are thorough and comprehensive, but their value is diminished if they are unable to address a number of challenges. Firstly, the rapid pace of technological change requires a technology plan to be a "living", evolving document that can respond to these changes.

Secondly, students have increasing amount of technology in their homes; schools must acknowledge and reflect this reality. Schools face the challenge of preparing students for changing professional lives and might have to shape and support what could be called a new breed of students. Students' expectations towards learning and teaching are likely to change as well (Akbaba & Kurubacak, 1998). Schools must be cautious though, because providing access does not ensure use in the classroom. Similarly, use in

the classroom does not ensure improved or enhanced learning.

Finally, technology planning is not a linear function; it involves many departments and processes occurring simultaneously, receiving feedback from each other before moving on. For example, professional development, budgeting, planning for infrastructure, needs assessment from teachers, curriculum and schedule changes, updating existing resources all occur at the same time and are interconnected.

There is no single model of technology implementation that is both comprehensive and evolving, addressing both macro (administrative, top-down approaches) and micro (teacher and classroom based) perspectives. Teachers' acceptance is probably the most important determinant of how well technology will be used in the classroom but other processes support this. Technology planning and evaluation requires more than a one-shot plan; it involves several processes occurring simultaneously, not sequentially, and it is an on-going activity. Any model must represent a dynamic or even cyclical implementation and adoption process.

Capability Maturity Models

W. Humphrey developed the first version of the CMM for software in the early 1980's at IBM (Sommerville, 2001). It was further refined at the Carnegie-Mellon Software Engineering Institute as a project funded by the United States military to assess software companies (Gainer, 1998). Since then, variations have been developed including the SW-CMM for Software, P-CMM (for people and human resource practices), SE-CMM for assessing Systems Engineering, to name a few variations (Carnegie Mellon Software Engineering Institute, 2002).

Each level of a CMM is characterized by key process areas, goals, and practices, which are "defined, implemented, and improved." (SSE-CMM, 1999, p. 37) According to Gartner Research (2000), "As an...organization progresses from one level to the next, its culture is transformed through the evolutionary improvement of its development processes."

Humphrey realized that adoption of a new practice starts with awareness, learning more, piloting the innovation, and achieving mastery. He realized that long-term adoption does not work when this model is applied to a single framework so he developed a model that would address the entire organization. One of the fundamental principles of the CMM is that a process cannot be improved if it can't be repeated (Curtis, Hefley, & Miller, 2002). Hence, to move from the first level to the second level occurs by repeating successful processes. At this second level, the environment is more stable and a foundation is provided for the creation of common practices. The third level identifies best practices, and then proceeds to integrate them as common practices. Documentation is the hallmark of this level. At this level, a common culture begins to emerge, based on common practices and beliefs within the organization. At the fourth level of maturity, the organization uses data from its activities to help manage future performance. The premise for this is that managing quantitatively provides predictability. Once a process is stable and predictable, it is possible to improve it. The fifth level involves continuous improvement. Change is accepted and people in the organization are empowered to implement change themselves.

In a CMM, the five levels have different characteristics depending on the application domain, although there are similarities. By definition, the entire organization

is classified at only one level, even though characteristics of a higher level may appear in some processes. Within each level there are Key Process Areas that help to define that level. Because KPA's are dependent on the application domain, they will not be described here as part of a general model, except to say that Key Process Areas all have goals, abilities, activities, methods for monitoring implementation, and methods for verifying or evaluating implementation (Pressman, 2001, p. 25). Most CMM's have three to four KPA's for each maturity level. Each KPA has two to three goals, and each goal has four to six key practices. (Pfleeger, 1998; Curtis, Hefley, & Miller, 2002).

Research in the software development field has determined that by applying the SW-CMM, organizations improve the software process, reduce the number of faults per project, and save money in the development phase (Curtis et. al, 2002).

Applying a CMM to K-12 Education

Given the shortcomings of other school technology integration models, and that the CMM was first developed as a technological innovation model for organizations, it is reasonable that the CMM be applied as a framework for technology innovation in schools. While schools are not concerned with reducing cost to bring a product to market, they are concerned with improving processes, keeping the cost of technology under control, and reaching their goals of improving the quality of education. It is even more suitable in that a CMM framework provides a mechanism for planning and evaluating on an on-going basis, responding to external forces and addressing internal processes.

It should be noted that a Technology Integration Maturity Model is not a technology plan, rather, it is a snapshot of the institution's current practices. Technology

planning is only one metric of assigning a level. A maturity model identifies strengths and weaknesses, opportunities for improvement, and establishes benchmarks against which practices can be evaluated and goals for improvement. Technology plans are usually concerned with financial planning, acquisitions, distribution, and services. Hoffman (2002) cautions that good plans do not necessarily result in good programmes. For example, a good writer may develop an exemplary plan that is never carried out. There is limited evidence that technology planning leads to better results, beyond equipment acquisition. (Brush, 1999).

Schools' adoption and use of innovations are influenced by many factors and adoption of technology is a continuing process. The concept of maturation is very appropriate in this context as the rapid pace of technological change affects all organizations, pressures from the work world encourage schools to adopt new technologies, and teachers themselves are dynamic practitioners whose philosophies and practices change and evolve (Becker & Ravitz, 1999). These factors all suggest that schools do pass through different phases of technological maturity. Ideally, this maturation is in an upward trend, although, it is theoretically and practically possible to move backwards or not develop at all.

Chapter 2 Research Design and Method

Research Design

A collective case study method of six schools was used. Data were collected regarding each school's technology plan and the teachers' attitudes toward technology use, as well as samples of technology projects. The case study method was selected so that the key process areas, goals, and practices, which define each level of the maturity model, can be "grounded" in the data collected from real schools. Use of a single case was deemed insufficient because the TI-CMM is meant to be a generic model useful to all K-12 schools. A collective case study will reveal commonalities among the sample schools, and illuminate differences, which are equally important.

Although the basic "skeletal" framework of a CMM model is being used, a qualitative approach is necessary to "add the flesh" to the model by identifying the technology concerns and practices within each school. All interview questions were designed to reflect the basic components of a generic maturity model as this is the foundation for the research project. Multiple means of data collection were used at each school to collect data that could address issues of documentation, repeatability, innovation, and standardization. The data were rich and broad, including financial information, specific computer models, and professional development, and teachers' attitudes and use of technology. A similar approach was used by Ives (2002) in her examination of University technology models, specifically for laptop universities.

Research Method

Data were collected from four sources at each school: an interview with the Principal or Head of School, an interview with the technology coordinator or IT Director, examination of technology plans where permitted, and a teacher survey of attitudes toward technology. Multiple English high schools, both public and private, were solicited to participate by letters to their Principals or Heads. Of the schools that agreed to participate, three are private, one is a private parochial school, and two are public. It was not expected that each school represents a level in the CMM; rather, it was expected that each school would represent different practices, different planning methods, and differ in the amount of technology available and how it is used, and consequently provide insights to issues of each level of the TI-CMM.

Maximal variation purposeful sampling was used to identify some of the schools that were asked to participate. Because I am a technology coordinator at one of the schools in the sample, I have knowledge of the technology programmes at other schools. Two of the schools were selected because they have a one-to-one laptop programme at some of their grades, which is a less common approach to technology. It was important to include some public schools, to balance the private school perspective. The two public schools agreed to participate because I agreed to compile and share the data from the teachers' technology survey with them for their own interest or for planning purposes.

All interviews with Principals and technology coordinators were tape-recorded, except in one case where the administrator and technology coordinator involved were not comfortable being recorded. In this case, I took as many notes as possible during the interview and transcribed the notes within three hours after the interview.

Administrator and Technology Coordinator Interview

An interview protocol for the Principal and one for the technology coordinator were designed and used to conduct the interviews (Appendices E and F). Questions relate to issues that define each of the maturity levels, including documentation, use of technology, professional development, availability of resources and infrastructure. In order to confirm data, some questions from the technology coordinator interview are repeated.

If the Principal was unable to participate, then I requested an interview with another senior administrator. Participants were asked permission to tape record the interviews. I transcribed all interviews myself.

Teacher Questionnaires

The teacher survey was composed of two instruments (Appendix G). The first is the Technology Implementation Questionnaire developed by Wozney, Venkatesh, and Abrami (2001) at the Centre for the Study of Learning and Performance at Concordia University. This is a comprehensive questionnaire examining teacher use of technology and their reasons for integrating or not integrating technology into their classrooms. While the initial purpose of this questionnaire was to examine the reasons teacher do or do not integrate technology into their classrooms, in this study, it was used to determine the extent to which teachers do use technology and whether or not they see it as beneficial and cost-effective. Technology will be defined for the teachers as computer software and Internet use. Permission to use the TIQ was granted by the authors.

The second instrument is a researcher-designed questionnaire, Teacher Technology Activities Questionnaire, asking teachers for examples of how they use technology in the classroom. The TIQ provides a benchmark to assess the state of technology integration in each school at an instance in time to be used as a comparison to the plans that were developed and implemented by each school's administrator.

Collection of Technology Plans

Each school was asked if it would provide or allow me to look at copies of their technology plans or relevant documents that they have now or have used in the past. Confidentiality was assured, although not every school could comply with this request for reasons explained in the description of each school.

Chapter 3 Data Collection and Analysis

Obtaining permission

Letters of permission explaining the purpose of this study were sent to all secondary high schools within two English school boards, as well as a number of English private schools (Appendix A). Appointments were made with the Principals and IT Directors of the six schools that responded positively. In exchange for their participation, I offered to compile and report the results of the TIQ for each school so that the administration could use this information for planning purposes or just for general interest. Of the six schools, I am employed at one of the participating schools; in three of the schools, I had some connection with either the Principal or IT Director, and so they agreed to participate, and two schools participated because the principal or IT Director was eager to have the TIQ results from their teachers.

Data Collection

All interviews, except for two were tape recorded and transcribed. Short notes were taken at the same time. When the interviews were not recorded, I expanded on my notes immediately following the interview. In two schools, the administrators arranged group interviews because of time constraints.

The TI questionnaire was distributed by the principal or technology coordinator to all teachers in the school and teachers voluntarily completed and returned it. The school with the best response rate had teachers complete it at the beginning of a staff meeting and return it at the end of the meeting. This was not, however, the school whose principal agreed to participate in order to get the results of the questionnaire. The response rate at

most schools was disappointing probably because the teachers had no reason for completing the questionnaire, they did not know me personally, and according to almost all of my liaisons, the teachers are quite busy and do not generally take the time for surveys unless they are compulsory. I was even disappointed by the response rate in my own school, although I made several requests to teachers to complete and return the survey.

Analyzing interviews and teachers' comments

Transcripts of interviews and teachers' written comments from the TIQ were analyzed by hand using content analysis. Most written responses from teachers were given in point form. This information was transcribed exactly and then in-vivo codes were used to quantify and organize the types of responses, which were then reorganized into topics. The names of the schools and participants who were interviewed have been changed. For consistency and more anonymity, I have changed all names to male names, even though the participants were not all men.

Cleaning the data and missing data

Data were first entered into an Excel spreadsheet. Each school was assigned a numeric code, and each participant within each school was numbered. The school and participant code were recorded on each answer sheet. Once the data were entered, I chose eight answer sheets at random and double checked the entries. Questions 3, 5, 8, 14, 17, 23, 24, 25, 27, 29, and 31, were negatively worded and so the answer values were changed to reflect this. For questions 1 to 33, missing values replaced with average of

other questions 1 to 33 for same participant in order to better represent that person's attitude. One participant from school 2 was eliminated because 10 questions were unanswered. Missing values for question 35 (years of teaching) were replaced with average of entire sample (all teachers from all schools). Missing values for question 37 (preferred teaching methodology) and 44 (frequency of using technology for instructional purposes) were replaced with the mode of the entire sample (all teachers from all schools). The Excel data were then transferred to SPSS for analysis. Survey results are discussed after the school descriptions.

Results: Description of the Schools, Interviews, and TIQ

To develop a broad depiction of each school, the TIQ results, description, and interview comments will be presented by school. Tables describing each school's computer inventory, support, and TIQ summary are provided before the descriptions to provide the reader with a basic "snapshot" of the school. Table 1 provides a summary of computer inventory and the number of users at each school. Table 2 briefly describes the support for this technology.

Table 1 Computer availability at each school

	# of teachers	**# of students**	**# of computers available for teachers**	**# of computers available for students**	**Notes**
School A	68	555	68	144	Increasing computers for students next year (laptop school)
School B	50	430	50	1 to 1 in Grades 7 – 11, 1 lab of 25 desktops & carts of laptops available in younger grades	Laptop programme in grades 7 - 11
School C	85	760	80	250	Mostly desktops, a few laptops
School D	51	900	100	100 computers in 4 labs	
School E	25	325	They can use the student lab	30 computers in 1 lab	
School F	55	800	10	80 computers in 3 labs	

Table 2 Technology support at each school

	Technology Plan	**Curriculum Support**	**Technical Support**
School A	Yes, 10 years, reviewed yearly	2 part-time teachers	2 full time technicians
School B	Yes, 5 years, reviewed yearly	2 part-time teachers	1 technician and IT Director
School C	Reformulating 5 year plan	none	1 technician and IT Director
School D	School Board umbrella plan and principal's unwritten plans for school	Computer teacher has some release time	School board technician once every 10 days
School E	No	1 teacher part time	Contract with an outside company
School F	School Board umbrella plan, no school plan	Computer teacher has some release time	School board technician once every 10 days

The TIQ data are treated as ordinal values and descriptive statistics are provided. Because the n sizes are small and vary significantly across schools, it would not be valid to compare results between schools. Consequently, the interpretive usefulness of the TIQ results is diminished. Table 3 shows the return rate by school.

Table 3 Rate of return of questionnaires

	# of questionnaires distributed	# returned	# of responses to written questions	Rate of return
School A	68	24	21	35.3%
School B	50	8	8	18%
School C	85	50	45	58.8%
School D	51	12	8	23.5%
School E	25	11	6	44%
School F	40	12	6	30%
TOTAL	319	117		

Table 4 summarizes the descriptive statistics from the TIQ for each school. These data are provided for interest only, as comparisons between schools are not valid. Questions 1 through 33 of the TIQ use a scale of 1 to 5 to measure teachers' attitudes toward technology in terms of the three categories: a) how highly the teacher values using technology in the classroom (value), b) how successful the teacher believes it will be (expectancy), and c) how high the teacher perceives the cost of this implementation to be (cost) (Wozney et. al., 2001). These composite values were calculated as the mean of the responses for each question in these three categories. The scale for the Mean Proficiency Level score is 1- Unfamiliar, 2- Newcomer, 3-Beginner, 4- Average, 5-Advanced, 6-Expert. Mean stage of integration uses the scale: 1-Awareness, 2-Learning, 3-Understanding, 4-Familiarity, 5-Adaptation, 6- Creative Application. How often teachers integrate technology was listed in hours per week. How often teachers integrate technology is based on the scale 1- Not at all, 2-Rarely , 3-Occasionally, 4-Frequently, 5-Almost always ,6- All the time.

Table 4 Descriptive statistics for the TIQ responses for each school

	Value	Expect-ancy	Cost	Mean proficiency level	Mean stage of integration	Mean: how often do you integrate tech?	Mean hours per week of personal use
School A	4.34	4.40	3.81	4.29	4.69	3.29	4.13
School B	4.46	4.50	4.30	4.50	5.25	4.63	4.38
School C	3.88	4.12	3.47	4.20	4.35	3.20	4.16
School D	3.98	3.98	3.59	3.75	3.75	2.17	3.42
School E	4.01	4.17	3.85	3.73	3.91	2.45	4.55
School F	4.42	4.10	3.90	4.42	4.63	3.54	4.50

School A

This is the school where I work, so I am familiar with their usage and technology plan. Still, I interviewed the Headmaster and the other IT Director.

School A is an independent school for boys offering Kindergarten to Grade 11. The campus has two buildings and a third building is presently being constructed in a wealthy suburb of Montreal. According to the Admission's office the school has a reputation for excellent academics, a strong athletic and arts programme, and all graduates go on to post-secondary education, often at prestigious prep schools or universities.

The school has a wealth of technology including two desktop labs, four sets of 24 laptops stored in mobile carts, every teacher has his/her own laptop, and every room in the school is wired for network and Internet access. In September 2003, the school will be implementing a one-to-one laptop programme where every student in grade 7 and 8 will be assigned his own laptop. This programme will expand into Grades 9 through 11 in the following year. Laser printers, many digital cameras, scanners, and video cameras are available for teachers and students to use at school. There are also two full time technicians at the school, and two teachers have reduced course loads so they can provide computer integration support to other teachers. The IT Director mentioned the importance of human resources to maintain and support the computer programmes.

The administration is very supportive of the use of technology within the school and this is manifested by large sums of money allocated for technology every year. There are two administrators in charge of technology, one overseeing administrative uses and one overseeing pedagogical uses. A formal technology committee, composed of the IT

directors, headmaster, two teachers, two board members, and one parent, meets monthly. A long term, comprehensive technology plan has been created and it is revised yearly. This plan is represented by a large multi-sheet spreadsheet that shows the current cost of technology and projected costs, based on hardware acquisition and allocation across the school in the next five years. Some software costs are included as well.

My interview with the headmaster was informal as he did not have very much time. It was not tape recorded, although I made notes immediately after leaving the meeting. He felt that the IT Directors could answer my questions. He talked about technology "throughout the curriculum", he felt that the one-to-one laptop programme will better prepare students for their future after graduation, and he was proud that the school was able to develop and implement this programme. He stated that he is not the computer "champion", but his skills have improved dramatically since he has had is own laptop, he uses it more, and he believes that this is true for most of the teachers. As an administrator he believes in the programme and feels that his role is to fund it and provided the required resources.

Twenty-four of 68 teachers responded to the TIQ although it was necessary for me to request several times that they be completed. Once again, many teachers had good intentions and wanted to fill it out, but their days are quite busy, and it wasn't a priority for them. The TIQ cover letter for this school assured teachers that, even though I am involved in computer planning here, their responses were being collected for a different purposes. Responses were thoughtful, but some still included specific requests to me. All teachers noted ideas and projects that they have used or would like to use. They did make requests for extra projectors and digital cameras, and like the other teachers, they

requested more professional development, and they suggested a format. They did not request skills workshops, but "project" workshops. They also showed a "balanced" attitude toward computers, which was expressed by one teacher as: "Make it one trick in your bag, not your bag of tricks." Comments were all positive toward technology, including "[technology] allows me to do things I couldn't do otherwise."

School B

School B is a private, girls' school located in an affluent residential area offering Kindergarten through Grade 11. It does not look like a typical school, and like many private schools, the doors are locked, and one must ring to be let in then sign in with the receptionist. Once inside, student artwork is displayed throughout the school, and I saw several girls sitting around working on their laptops while waiting for parents to pick them up. The atmosphere was quiet and calm, although I was told this isn't always the case.

School B has a one-to-one laptop programme where each student from Grades 7 to 11 has his own laptop which is rented from the school. In the younger grades, laptop cupboards are provided in the classes. Every teacher is assigned a laptop as well.

Their IT Director, John, is a quiet and friendly person. In addition to being the IT Director, he provides technical and curriculum integration support and teachers one or two science classes. The school has a 5 year technology plan, which they call an Action Plan, reviewed yearly. The plan includes laptops, software, and servers. When asked who develops the plan, John responded, "I do." Although there is a technology committee

comprised of the Head, some Board members, the IT director and some teachers, John said that he writes the plan and they basically agree to it.

John is certain in his belief that providing technology to each student improves their learning experience and used the term "ubiquitous" to describe the use of computers at the school. He talked about multiple learning styles, student centred learning, developing active learners, and putting the onus on the student to complete work. He believes that laptops support these goals. When asked what he is particularly proud of at this school, he replied "I don't know." He did not hesitate when asked what still needs improvement: he said that they still have to get computers available to every student.

John helps teachers if they need ideas to use computers in their curriculum, and he has developed a database of ways to integrate the laptops at each grade level in each subject, focusing on published standards. There is another teacher at the school who provides support for teachers when they request it. The school provides funds for courses and conferences, they offer weekly in-house classes for teachers to improve their skills, and he encourages teachers to help each other.

John never discussed computer science courses or curriculum, although he did mention some sophisticated software packages used for digital imaging and movie making.

The Head of the school was very complimentary toward John's effort and hard work in developing their laptop programme. He noted his "vision" and the fact that he is also a teacher allowed him to "model" the use of the laptop in classes. He was very proud of the teachers' ability to embrace technology and "renew" themselves as teachers, attributing this to assigning teachers their own laptop. He also believed in the importance

of exposing girls to science and technology and discussed how he, as the head of the school, can interact with students through electronic conferencing and email and that it provides students with easy access to him.

Only eight out of fifty teachers returned the TIQ from School B. Teachers at School B complete a number of questionnaires regarding their laptop programme, so John and I speculated that perhaps they were tired of responding to surveys. Some wanted easier access to projectors and video cameras, but all of the responses were about how to use computers within their subject area and were positive about the laptop programme. For example, one response was, "We are in the enviable position of having all our students equipped with laptops and we have a wireless environment. The computer is ubiquitous at School B." Another positive comment: "The resources are fabulous and the students were constantly in inquiry mode. The excitement and sharing of ideas was facilitated by email and conferencing."

School C

School C is an independent, co-educational K-11 school. The school has a very serious, professional atmosphere, and a reputation as being an excellent school that provides a solid academic education and good physical education facilities. Virtually all graduates move on to post-secondary education, and it is one of the few schools in Quebec that offers a Grade 12 year for students wishing direct entry to university outside of the province. One senses that the school is proud of its history; students wear uniforms and teachers are very well dressed. The reception desk is more reminiscent of a corporate office than a school.

The Head of the school arranged a group interview including himself, the Director of Curriculum, and the IT Director at the same time. These administrators are very interested in the results of the TIQ survey.

The discussion moved away from the prepared questions and a philosophical discussion ensued between the three men regarding the role of technology in education. All three agreed that the school had no concrete direction, and they were, in fact, rather "ambivalent" about its use in school. They questioned its value and wondered if the more emphasis a school places on academics, then the lesser the role for technology in the school. The administrators acknowledged the need to have computers in the school, if only in response to "parental pressure".

On another occasion, I had a private talk with the IT Director, who did not want our discussion tape recorded. He spoke of budget cuts (although he is working with a budget that would be the envy of many schools), server problems, and computer programming courses. As the Director of IT, he saw his role as a support position within the school and he wasn't convinced that computers have a useful role in the classroom except on an occasional basis and mentioned that some students and teachers were very enthusiastic about some digital videos they created. He mused that he his own educational experiences may be too entrenched for him to accept "new ways". He commented on other private schools implementing laptops programmes, and he could not see the pedagogical value in them. Contrary to the previous teacher quoted, the administrative vacillation was again reflected in several teachers' comments that the school should have more laptops for teachers and students, and several mentioned the need for a laptop programme that some of the other private schools use.

School C had the best response rate on the teachers' TIQ. It was distributed by the administration at a staff meeting and teachers were asked to submit it at the end of the meeting. From 85 teachers, 50 questionnaires were returned, and the written comments showed a greater variance in attitudes toward technology. Interestingly, this school has the lowest mean for the attitudinal trait values. This might suggest that school administrators' less-than-supportive attitudes or their "ambivalent" stance may be reflected by teachers. This school also had the highest rate of return because the survey was given during a staff meeting, so I cannot dismiss the fact that the results may have been influenced by the data gathering procedure. For example, teachers may have resented having to fill in the questionnaire or having to attend the meeting. These confounding variables make it difficult to interpret these results.

Some teachers' written opinions echoed the administrators' "ambivalence", while others were more decisive, writing that he/she was not interested in learning to use computers in the classroom "WITHOUT spending the little time I have been given to teach my subject using TRADITIONAL AND SUPERIOR means!" (sic). Almost all teachers commented not only on the need for more professional development, but they had ideas as to the format it should take. Suggestions included peer coaching for technology, no formal instruction but time to work with teacher partners on technology projects, and tailoring the instruction to each teacher's skill level. Finally, all of the teachers had some ideas as to how to use computers in their subject area.

School D

School D is a typical, large suburb public high school, housed in a sprawling, concrete building that looks to be at least 40 years old and requires some maintenance on the building. It is surrounded by large athletic fields and shares its building with a college and a nonprofit organization which refurbishes older computers for schools, hospitals, public libraries, and charities. Students were typically boisterous during both visits to the school, and administrators were busy with disciplinary matters.

The principal of the school, Robert, was eager to meet with me as he was interested in his teachers' results on the TIQ, even stating that he would like to administer it again in a year or two to see if there is a change. Robert's office is a typical principal's office with a desk, chairs, and a small conference table, but it was full of books on leadership, change, vision, and how to effect change in schools. My correspondence with Robert had been almost exclusively via email, and he answered his emails promptly. In addition to a desktop computer on his desk, he carried a new, thin, and lightweight notebook with him, which he purchased himself. Robert had just been assigned to this school in the previous summer, and he stated that he was chosen to lead this school because of his passion for and belief in technology. Indeed, he spoke at length about his plans for using and implementing technology in the school, not waiting for me to ask questions. His first task at the school, which he started the first day on the job, was to ensure that every classroom and office was networked and has Internet access. He believes that educators spend too much time talking about hardware, software, and technology use in the schools but not how it can improve learning. Having said that, he then spent a good deal of time discussing computer hardware in his school, although I

believe he is sincere in his belief that it can improve learning. He is an advocate for "real world" projects that require students to do computer projects that will actually be used or displayed or in projects that mirror a "real life" application. For example, instead of choosing any topic for a movie making project, he has students make promotional movies about their school to be shown at the school's open house. At the school there is a team of students who provide technical support and then they mentor younger students to take the job when they graduate.

Robert discussed the School Board's five year plan for technology that was just finished. Unlike my experience at another public school, which was part of the same school board, Robert feels that the school board is generous in allocating funds for technology to each school. The school itself has no formal technology plan; although Robert has plans, he just hasn't recorded them, or seen a need to formalize them. He noted that the funding allocation for technology was not large for each school; he was unconcerned by this. He noted later that he had other sources of funding, for example, from accepting student teachers, and that as principal, he can use his discretion and apply these funds toward technology projects or equipment. Robert doesn't believe that you need the latest technology to do worthwhile computer projects with students. In fact, my impression of Robert is that he isn't the type of person to see barriers, and if he does see them, he simply finds a way to work around them.

Another one of Robert's initiatives was to hire 10 new teachers who, in addition to being able to teach more than one subject, were comfortable with technology. He was going to further push the agenda by creating on-line conferences for each department and publishing relevant documents from his office to these conferences as an incentive for

teachers to begin using email and conferencing. At the same time, Robert is realistic and knows that some teachers will never use it, but he plans to provide incentives for other teachers who need encouragement, and he wants to develop a "buddy" system so teachers can help each other learn.

One of Robert's favourite projects is the new Linux lab that he and his computer teacher managed to develop for only a fraction of the cost of a traditional computer lab using restored computers from "reboot" and a stagière from the college. Robert did not see funding as a hurdle large enough to prevent him from moving ahead with his plans. Brent, the computer teacher, was also proud of this lab, to the extent that it was all he wanted to discuss. His pride stems from the fact that this lab was fully functioning with standard application software, it had access to the Internet, and was developed for a small fraction of the cost of a traditional lab, and would have no software costs as the software is open source (freely available). Brent felt that the teachers would share his enthusiasm and that it would be booked often by other classes. The other labs weren't booked because of regularly scheduled classes in the lab. Brent was identified as the computer "champion" at the school, but he did not speak about curriculum integration into other subjects, and he only briefly discussed the curriculum of the computer science department. He could barely contain his enthusiasm for the new Linux labs, and his excitement stemmed from his belief that it is an ideal solution not only for schools, but for any cash-strapped organization such as hospitals, libraries, or charities.

Twelve of 51 teachers returned the TIQ at School D. Robert distributed it on a pedagogical day thinking that teachers would have more time on this day to complete it, but he was unable to follow up and it wasn't a priority for teachers. A strong theme

throughout these teachers' comments was the lack of resources (computers, software, and technical support) in their classrooms and the ability to book the computer labs. They all had ideas for using technology, involving packaged software, giving presentations to their class (PowerPoint), and using web sites. Comments about computer use were not negative, in fact, teachers seemed anxious to use technology, if it were more readily available: "I have found that when I take students to the computer room, some students who are never involved in the class suddenly start working. The problem is, subject teachers have little or no access to the computer labs."

School E

School E is a private, parochial school located in a middle-class suburb of a large city. As one of the few English parochial schools, they feel that they have a market niche, and their students come from all over the region. They are housed in a typical school building that is newer and kept very clean. Teachers and receptionists were especially polite and helpful, as were the uniformed students. The school has no formal IT Director, but the computer teacher, Shawn, was eager to discuss technology use in the school. As a classroom teacher and computer teacher, Shawn is interested in using technology, and he is trying to build greater technology momentum in the school by forming a technology committee to address short term goals, equipment upgrades, and acquisitions. The school does not have a technology plan, and this is something he wants the committee to develop. As a teacher, Shawn does not have control over funding. The School's administrator would decide if funds are available for software and technology, although Shawn said that the Principal would be supportive if he approached him with a need.

Shawn feels that in addition to more computers, they need more training for teachers. This was verified by the written comments teachers made on the TIQ. He believes that computer workshops are well received by teachers, but there is no time for these activities, as pedagogical days are planned with other activities. Shawn mentioned several projects he has implemented himself, but he noted that access to computers is difficult as the lab is often booked.

The school has one computer lab. The library, every office, and almost every classroom in the school is networked. Shawn is concerned that the computers in the classroom are older and do not have CD-ROM drives, which he feels is a requirement for their teachers. Some teachers take their classes to the computer lab, but there is no support person available to help them, as Shawn has his own teaching load. He feels that some teachers aren't confident enough to work in the lab. Shawn himself is proud of his use of technology with students, particularly a course in web design, and his use of technology in teaching English.

The principal of the school views Shawn as the person who would help to develop a long term technology plan, although this is an informal position, and his primary position is teaching. He stated that no single person "champions" technology at the school. He noted that it is the finance committee that makes decisions about technology acquisitions. He was proud of the school's computer lab and the programming course and spoke at length about how well graduates performed in college level programming classes. He acknowledged that technology acceptance among teachers is mixed, and he himself was not clear on its value, noting that it is not a panacea for all academic problems. The principal himself did not have a computer in his office and suggested that

they did need more computers. My impression was that he did not know how to answer some of my questions and was uncomfortable discussion technology. Our meeting was brief.

Eleven of 25 questionnaires were returned by teachers at School E. Their comments echoed Shawn's opinion regarding the need for more training, and while these responses showed enthusiasm for using computers, they also demonstrated some uncertainty as to how they could be used in the classroom as well as the need for increasing student and teachers' basic computer skills. Several times Shawn requested that the teachers respond to the TIQ, but it was distributed before their week long winter break, teachers were busy grading, and tired and it was not a priority for them.

School F

School F is a public high school located in a middle class suburb. Of forty questionnaires distributed, twelve were completed and returned. Like the other public high school, the building is an older, generic two-storey building with concrete walls and marble floors. The atmosphere is casual, but it was relatively quiet all three times I visited. The vice-principal arrange for me to meet with him and the computer teacher simultaneously, in order to accommodate their busy schedules. The vice principal, Michael, was frank in stating that he had no input into the technology acquisition or spending at the school. Also, he was relatively new at the school and so he deferred to the computer teacher, Nicholas, a veteran of the school, for answers to all computer comments.

Nicholas explained that they had a grant for computers, but the grant ran out this year. They have 3 labs. One room has 33 computers, another 32 and another 16. He expressed frustration with the technical support provided by the school board. The technician comes once every ten days, and he is limited in the amount of maintenance and software installation he can do himself because of security programs on the computer. He is also frustrated by the school board's decision making guidelines for allocating money to school for technology. They use the common metric of ratio of students to computers to allocate funds across schools. The problem, in his view, is that this metric does not consider the quality of the computers.

Both Michael and Nicholas felt that newer, younger teachers are more interested in using technology while older teachers do not show as concerned with computers. Both felt that this was because of the extra work required to learn to use computers, integrate them into your course, and then keep your skills up to date. Michael said that he himself has had to take evening courses on his own to keep his computer skills current, but he was glad that he did and felt they were worthwhile as he used these skills with his students. As an example, he talked about his use of PowerPoint and digital cameras. Michael will help any teacher improve their skills or work on a technology project, although he feels pressured; between helping others and teaching his own classes, his time is all used up. He has some release time from his principal but he didn't want to say how much, but many days he never leaves his lab. He used to run workshops for teachers on pedagogical days, but it isn't a priority on these days anymore, although he was unable to say why.

Michael discussed computer curriculum at the school and a switch from compulsory keyboarding and optional applications course (which previously was only for advanced grade 7 students). Now it is optional keyboarding and compulsory applications course for all grade 7 students).

Comments on the interview and TIQ data

When selecting comments from the data that would indicate Key Process Areas in the TI-CMM, some findings resonated with me either because of my role as a technology planner, because they re-occurred throughout the data, or because they were significant in determining a school's use of technology. Some of the themes from the data which influenced the development of the Key Process Areas for each level of the TI-CMM are discussed below. Specific comments used to develop KPA's are included in the following section.

Based on the survey data, the schools in the sample divided into two categories: laptop schools (School A and School B) and non laptop schools. That a school has a large array of computer equipment and peripherals does not mean that this equipment is used or used well. However, the two schools with laptop programmes scored higher on the attitudinal scales, integrated technology into classes more often, and rated themselves higher in terms of their stage of integration and proficiency level. A major component of the technology plans in these two schools was to provide laptop computers for almost all of their teaching staff. This result is not surprising in light of the results of the original TIQ survey which found that teachers' personal computer use was the highest predictor of classroom technology use (Wozney et. al., 2001). It seems that a certain amount of

skill training occurs automatically, outside of a formal structure, when teachers have their own computer to use at their convenience for school and personal use, which implies that the more technology that is available does lead to more pedagogical use. It seems that makes sense to provide computing resources to teachers before students. Some schools with high access to technology within the school still note limited use within the classroom which, according to teachers' comments is because they are not comfortable with the computers, packaged software they wish to use isn't available, the technology isn't available when they wish to use it, or they see it as an "add-on" and are limited by time-constraints within their courses.

Not all administrators or teachers agreed that there is value using computers and technology in schools. When interviewing IT Directors, there was an atmosphere of high, yet unfulfilled, expectation regarding the use of technology in schools. When they did believe it was beneficial, the reasons were stated in very broad and vague terms. Some phrases from IT Directors and teachers include: "access to greater information", more "student-centred approaches", and it "provides real-world experience" for students. Such obsequious definitions do not provide a metric for establishing which computer activities are educationally worthwhile. It is problematic to implement an innovation without having some goals with which you can measure and compare results.

All administrators agreed technology plans are valuable. Despite extolling the pedagogical virtues of computers in the classroom, many administrators and technology directors then proceeded to discuss the make, model, and age of the computer, processor speeds, RAM, peripheral devices that are available, and software. Administrators did not discuss how the computers were used. Nicholas's frustration at using the computer-to-

student ratio for evaluating schools is worth further consideration. His concern was that this ratio does not consider the age of the computers, but it also does not consider actual use. The mere presence of a computer does not ensure its use by students or teachers.

Every school could identify a technology "champion", but that person makes a difference only if he/she is a senior administrator, has influence with a senior administrator, or has budgetary control. This person must be very persuasive, dedicated, diplomatic, and tenacious. From this study, it became apparent that the role of technology champion should not be underestimated. In a typical CMM, organizations that are too dependent upon an individual are given a lower rating, but in terms of technology in schools, the role of technology advocate is vital in acquiring resources and encouraging integration, consequently moving the school to a higher level of use.

While it seems reasonable that technology plans are developed by a committee with input from the major stakeholders within a school (administration, teachers, staff, students, parents), in this study of six schools, those with the most effective use of technology had plans that were largely individually driven. These plans were created by the technology "champion", who, possibly after surveying others, acquired the necessarily senior approval, and then oversaw the implementation of the plan. These people seemed to be in touch with the needs of the entire school population.

In addition to the computer "champion", senior administrators also must act as advocates for technology in their school. Some authors suggest that school leaders who are technically adept are more effective advocates (Michael, 1998). I would say that while this would be useful, it is not necessary if the principal or head of the school

demonstrates his/her support by attending computer workshops, provides funds for training and technology plans, and gives verbal encouragement to his/her faculty.

None of the schools have plans for professional development or teacher training beyond providing funds for it. The format of the plan and the types of skills required by teachers were never specified.

The schools that did seem to integrate computers well spent very little time discussing the traditional computer lab and the computer science curriculum, while other schools saw computers only in this context. Since the point is to embed the use of computers and related technology within all curriculum areas, comments from these schools were indicative of higher levels on the TI-CMM.

Almost all of the administrators discussed the implications of expanding technology use in hiring of new teachers. Some felt that computer use would increase as younger teachers enter the profession, but at the same time, felt that teacher education programmes were not preparing novice teachers well enough to use technology or providing enough computer courses. One administrator from a laptop school mused that this was an even greater problem for laptop schools and suggested laptop schools may create a group of specialized teachers.

In their written comments on the TIQ, over and over teachers lamented the lack of time for computer training and preparing for computer activities. Several teachers noted that the burden of learning and/or improving computer skills is often left to the teacher's own time, unlike workers in the corporate sector who are trained on company time. What is important is not the accuracy of this perception, but rather the pressure teachers are feeling which affects their motivation to improve their skills.

Most technology plans were explained to me, and I was allowed to examine three. None of the plans focused on student outcomes. The plans were concerned with financing, acquisition, distribution, and occasionally funding professional development. This is understandable given that computers have only been in schools for a relatively short period of time, and that computer and software are changing so rapidly. It is not just a daunting task, it may seem almost impossible to discuss student outcomes, in the context of rapid change.

From the written answers provided on the TIQ, the most commonly mentioned topics by teachers included professional development (how much and the format of the training), resources available (usually stating more hardware, software, or human resources were necessary),

Teachers' Use of Technology

From 117 returned teacher Technology Integration Questionnaires, 97 included written comments. The teachers' comments were grouped into common themes which are summarized, along with their frequency, in Table 7. Each theme occurred at every school. Teachers from Schools A and B more often listed activities they were currently doing or had done in the past with students, while teachers from the other four schools more often listed suggestions, activities they would like to try, or changes they would like implemented at their school. This information was relevant when assigning comments and characteristics from each school to indicate Key Practice Areas at each level of the TI-CMM. Comments from School A and B tended to represent higher levels.

Table 5 Themes from teacher comments

Common Uses/Concerns	Frequency
Professional Development	44
Presentation (multimedia, video)	36
Internet	35
Educational Software	32
Word processing	27
Positive attitude toward technology in the classroom	18
Need for more resources (hardware)	17
Need for more time to learn/integrate technology	15
Spreadsheet or Database Activities	13
Motivation	7
Negative attitude toward technology	7
Computer as a "tool" analogy	7
More professional development or human support	6
Graphing Calculators	5
Laptops	5
Portfolio	4
More technical support	4
Collaborative opportunities via technology	3
Robotics	3
Basic computer skills (file management)	2
Concerns about how to assess technology projects	1

The purpose of a TI-CMM is to generate practices that encourage more and effective use of technology across the curriculum. Two types of practices results: those that encourage the use of technology, and the actual use of technology within the school. Before discussing the development of the TI-CMM, it was necessary to determine if and how teachers were using technology. To do this, lists of computer and Internet activities are compiled and then organized by type. The most common uses of technology were categorized as Internet use (research, creating web pages, WebQuests, (Dodge, 1995),

word processing, presentations (e.g. using PowerPoint), and specific educational software.

Seven teachers mentioned the "tool" analogy where computers are a tool in the classroom, and should not supplant other instructional tools. This was also mentioned in several interviews and seems to be a common perception among educators toward technology. One participant stated, "Make it (technology) one trick in your bag, not your bag of tricks."

Computer activities were usually described in terms of the software used and subject used, often including a very brief description of the activity. Paradoxically, several teachers mentioned the same technology use as an example of a worthwhile activity and as an unsuccessful activity. For example, a teacher mentioned that a student group's video was very well done and had been a "valuable" as the students had learned a great deal and worked together as a team, but this teacher considered another video project to be a "disaster", although no explanation for this was provided. One can speculate upon any number of factors: that the teacher did not have clear learning goals for the lesson, perhaps these learning goals weren't communicated well to the students, or perhaps there were hardware or software problems. It would be useful to determine what factors contributed to the same technology being used successfully once and unsuccessfully another time; such information should be used when instructing teachers on how to integrate computer technologies in their classes. The technology must be situated within good instructional practices including lesson preparation and assessment. Only one teacher mentioned assessment as a topic for professional development.

After listing all technology activities described by the teachers and how they were embedded within each subject (when this information was provided), I found no pattern in this data in itself. One IT Director made use of the National Education Technology Standards for students and teachers from the International Society for Technology in Education (ISTE, 2003). These standards are reproduced in Appendices H and I. Although useful at a macro level, these guidelines are deliberately vague in specifying how to accomplish specific goals.

A representation that suits the data better is Ainley et. al.'s (2002) use of a two by two matrix of cognitive processes using the revised Bloom's Taxonomy (Anderson, et. al., 2001). Presented in Table 6, this grid gives teachers a guide for considering the possible cognitive outcomes of a computer activity. At the micro level, classroom implementation, it is a useful framework for situating the lessons mentioned by teachers. In Table 6, I have included some of the sample computer activities mentioned by the teachers. In most cases, I have tried to use software and activities mentioned by the participating teachers, although the activities in italics are suggested from my own experience.

Table 6 Sample computer activities in the Cognitive Process/Knowledge matrix

		Type of Knowledge		
Cognitive Process	**Factual**	**Conceptual**	**Procedural**	**Metacognitive**
Remembering	Internet research (eg. Earth and Space: who, what, when, where questions)	Scaffolding (SchoolKit activities)	Microworlds LOGO: basic turtle functions and syntax	*Scaffolding (SchoolKit resources)*
Understanding	a) Internet search as first step in solving a problem. (why & how questions) b) PowerPoint combined with oral presentation	Concept Mapping (Inspiration/Kidspiration)	a) Concept Map (algorithms) b) Microworlds LOGO: programming turtle to draw basic geometric shapes	Collaborative Discussions (FirstClass /email /messaging systems) where students and consult with each other
Applying	a) Peer editing (Track Changes in Word) b) Developing and organizing Web Pages	a) Geometer's Sketchpad	a) Microworlds LOGO: combining procedures to create more complex figures b) Digital Movie Making	Outlining notes, reducing notes, summarizing. (word processor)
Analyzing	Internet search for answers to open-ended questions ("Which city is the best choice for the next winter Olympics and why?") other justify, compare, which is better questions	Experiments: track data in Excel, change values, devise formulas (eg. How far do different toy cars go from a ramp? How does the mass of the car affect the results?)	a) Microworlds LOGO: Exploring polygons or Analyzing number sequences b) Designing and using databases.	Self-assessment tasks, electronic portfolios
Evaluating	WebQuests: verifying source of information	Solar System Simulator http://space.jpl.nasa.gov/	a) *Widget Workshop (simulations for young students)*	Peer assessment. Peer editing. May be done collaboratively via messaging systems.
Creating	Students create their own web pages.	*Electronic, illustrated historical timeline using Excel*	Students design and create their own WebQuests (not just web pages)	*Designing HyperStudio lessons to teach a concept & delivering instruction*

This matrix can be particularly helpful in the planning and assessment stages of a lesson. Some teachers responded on the TIQ that it is difficult to evaluate computer activities, and this concern was echoed by more than one IT director. Assessment can only be carried out once the goals of a lesson have been defined. It was suggested that computer activities are often used to captivate students' interest (which is not necessarily a bad thing to do), as an enrichment or remedial activity, or a reward. For the most part, these approaches do not require evaluation. It is also possible to work backwards, by selecting a location in the grid which teachers want to emphasize with students, and then deciding on a suitable computer activity. In this way, teachers are using technology not just as an "extra", but are aligning the activity with other learning objectives and evaluation.

The usefulness of this grid is in its simplicity. It is not prescriptive or subject specific, and all teachers should be familiar with the terminology. Initially, most teachers and students will be comfortable at the top left section of this grid, probably because less planning and fewer software specific skills are required here. As teachers become more experienced and confident in their own skills, they may attempt activities in other cells, and it encourages them to consider other factors that contribute to worthwhile technology lessons and realize that the use of technology itself does not ensure a successful instructional activity. This grid will be referenced at different stages of the TI-CMM.

Chapter 4 The Technology Integration Maturity Model

The TI-CMM provides schools with a framework for evaluating their progress of embedding technology into the curriculum so that it becomes a transparent, motivating, and useful educational medium. To evaluate progress, there needs to be a goal and a something to measure. An institution needs to define goals and evaluate its progress in meeting these goals. It is no longer enough to discuss technology implementation in schools in terms of hardware or software inventories.

Each level of the TI-CMM is defined by key process areas and outcomes. Key process areas identify clusters of practices that must be in place to reach that maturity level. The real utility of the model comes not from simply classifying a school, but in the application of the Key Process Areas to achieve the outcomes and then move to a higher level on the model.

Levels two through five of the TI-CMM have several Key Process Areas. Although other processes may occur, these are the "key" processes that are to be assessed at that level. The Initial level does not have key process areas as technology integration processes are still ad-hoc or limited to computer studies courses.

Outcomes are organized into four themes: Student Learning, Resources, Support, and Organization. These themes were developed after organizing and categorizing interview comments. Almost every comment made by principals and technology directors fit into one of these themes.

While the SW-CMM was the basis for the development of the Technology Integration CMM, the SW-CMM could not be directly applied to educational computing, nor was it possible to "overlay" it onto the collected data. This model was developed by

combining my impressions of technology use at each school as formed during the interviews, questionnaire results and observations with the descriptions and KPA's of the levels of the SW-CMM. Interview comments and written comments from the teacher surveys were compared to Key Process Areas of the SW-CMM and organized in a hierarchical fashion. Metaphorically, the details of each level were developed by taking the union of these two data sets. While it is difficult to detail this development, a table has been provided in the description of each level that illustrates the link between select quotations from the data with the KPA's of the SW-CMM which helped lead to the KPA's for each level in the TI-CMM. This process is illustrated using a three part table. The top section contains selected comments, the bottom left section lists the KPA's from the SW-CMM, and the bottom right section shows the KPA's for the TI-CMM. Comments were organized according to how often each school was using the technology, and how well it was accepted at their school. Not all quotations are included and similar quotations from other participants are not duplicated.

Each level is described below, followed by a table that shows the comments from the data, the KPA's from the SW-CMM, and the resulting KPA's for the TI-CMM. For each level, the KPA's were also informed by comments included at other levels as were the strategies to move onto the subsequent step. This is followed by a table listing the outcomes for the level, and then the practices enumerated for each KPA. Each process area contains a set of goals that, when satisfied, establish that process area's ability to enhance the effective use of technology within the school. These goals were also inferred from the administrators' and teachers' comments. Once a school has satisfied all of the

goals listed, it can then be classified at that level. Suggested practices to move to the next higher level are also listed.

Since this model is being proposed for the first time, there is no formal assessment of goal completion. Administrators and teachers will have to determine their status at each goal themselves. The model focuses on improvement, so there would be no benefit to inaccurately assessing goal completion. Indeed, it would be difficult to meet goals at higher levels if current level goals have not been met.

Level 1 Initial

At this level, technology is used only within the context of computer classes. Activities in these classes are based on learning to use basic computer applications (word processing, spreadsheets, keyboarding) and introduction to computer programming. Other computer courses may offer desktop publishing courses and may use digital cameras. In other subjects, use of technology, usually by visiting the computer laboratory when it is empty, is ad-hoc and dependent upon the interest and skills of each teacher. Consequently, technology use is not a priority of the institution, but dependent on individual efforts, which is characteristic of the Initial Level of any CMM.

Some teachers feel technology is useful but they do not have the opportunity to use it in their classes either because of time or equipment restrictions. They may use computers for Internet searches or use packaged educational software. These activities are not evaluated, and consequently, their value in terms of delivering curriculum and/or engaging students is unknown.

Within the school there are one or two computer labs, possibly more, and a defined computer curriculum. Each lab has 20 to 30 desktop computers. Most teachers

feel that there aren't enough technology resources within the school, and may feel that this prevents them from using it to improve their courses.

There is no formal technology plan for the school, although there may be global technology plans at the School board level. Money for technology is allocated to maintain the labs. The computer teacher is the recognized "computer expert", although he/she is busy teaching the computer classes and from time to time trying to maintain the lab computers when possible. There is no technical support on site, although the school board technician visits occasionally.

Professional development is provided by the School Board on pedagogical days, although this training usually focuses on administrative tasks such as how to enter grades in their reporting system. Senior administrators do not see technology as a pressing concern either because they lack experience with technology, they do not feel that it has a major role to play in education, or because the school has other priorities.

There are no Key Process Areas for the Initial Level. Movement to the next level will occur by providing network access to most of the classrooms, library, and offices, encouraging teachers to use visit the computer lab more often with their classes and to upgrade their computer skills, and by increasing the computer resources available to teachers and students. Table 7 lists some comments that helped me formulate the description of Level 1. Comments from the data are included in the top section, while the bottom left section lists the KPA's for the SW-CMM. The resulting KPA's for the TI-CMM are listed in the bottom right box. Note that there are no Key Process Areas at the Initial level, but there are several steps to take to move onto the next level.

Table 7. Linking the data with the SW-CMM to devise Level 1

<table>
<tr><td colspan="2">Level 1
"In a traditional high school … there's a computer lab or labs there's computer teachers and kids take computers as an elective it has no connection with the rest of the day." (School D)

"I'm not clear on its value (in the class)." (School E)

"Rreplacement is a major cash cow. It takes away from funds we can use elsewhere." (School C)

"It (technology)'s a novelty to some extent…may be useful but over hyped…still a fad." (School C)

"Some (teachers) are ambivalent, some comfortable, some aren't." (School C)

"There is no technology plan." (School F)

Are you (the Principal) the technology champion? "Not really, I have no credibility, not sophisticated enough, it's always supported, but I could do more." (School C)

"We do year to year planning (for technology)." (School E)

"Everything is done sort of ad hoc." (School E)

"Some teachers bring students to the lab. They go by themselves to the lab, there's no one to help them so confidence is a big issue. It depends on the teacher." (School E)

"(There's) not enough time for professional development. I do workshops on ped. days if there's time… the teachers like them all right, but I can't do everything." (School F)

"The (School) Board technician comes once every 10 days." (School F)

"How they allocate money for computers is a problem. The ratio of students to computers is a problem. If the ratio is too low no matter how old the machines then the board cuts funding." (School F)

"Most of the time I feel pressured. My time is all used up with classes. They say I have released time for this (helping teachers use technology), but I don't really have time for it." (School F)

"…no single person "champions" technology." (School E)</td></tr>
<tr><td>SW-CMM Level 1 Initial (TeraQuest, 2002)
This level is characterized by ad-hoc, possibly chaotic activity, and inconsistent management. Project success often depends on individuals;the organization is dependent on individuals and hiring outstanding employees.

No Key Process Areas

Move to the next level by Repeatable Practices.</td><td>TI-CMM Level 1 Initial
No wide-spread use of computers across the curriculum.

No Key Process Areas
Move to next level by:
1. Increasing the availability of computers and software to teachers and students.
2. Networking to classes and offices.
3. Some increase in teachers' computer skills.
4. Some increase technology use in all classes across all disciplines.</td></tr>
</table>

Level 1 activity should focus on moving to the next level. In general, this is achieved by increasing access and professional development opportunities. Professional development should also focus on valuing technology and its benefits to education including identifying learning objectives, linking activities directly to the curriculum, and how technology can provide learning opportunities not previously available. Despite having no Key Process Areas, there are some technology outcomes for Level 1, as listed in Table 8.

Table 8 Outcomes for Level 1

Student Learning • Most use of technology occurs within computer science or computer classes. • Technology use in other classes is infrequent.
Resources • Computer laboratories are available, but are not often used by non-computer teachers.
Support • There is no curriculum integration support and limited technical support.
Organization • No formal technology plan exists.

Level 2 Emerging

In a standard CMM, level 2 is called the *repeatable level.* Since classroom activities may or may not be repeated from year to year, I have called level 2 of the TI-CMM the Emerging level, indicating expanding computer use and that technology is emerging as a medium with a more important curricular role.

More teachers are showing an interest in using the computer labs as they feel it is a reward for the students and/or it motivates the students. They generally use activities situated at the lower left of the Cognitive Process/Knowledge matrix with Internet

searches and word processing as the most popular applications. Teachers would like to learn more, but they want to have professional development on pedagogical days or after school. They feel they lack the skills to use the technology although they are interested in using it. Many teachers express interest in learning to use PowerPoint presentations, or other packaged, subject specific software, and math teachers use graphing calculators.

The computer teacher works with other teachers to help them use technology. Teachers feel they need more access to computers and related hardware (e.g. projectors, digital cameras) and software and would like this equipment placed in their classrooms or accessible in offices. More technical support is provided for the computers in the school, and there may be more technology present in the school. More locations within the school are networked, including offices, the staff room, the computer labs, and the library. Clusters of computers with Internet access are available in the library. Some classes may have network and Internet access.

One person is acknowledged as the technology champion (who may or may not be the computer teacher), but he/she does not have the administrative influence or budgetary control to affect changes required to move to the next level of the TI-CMM. Perhaps this person does not have the personality or tenacity to keep pushing for additional resources.

The technology plan is developed on a yearly basis as the school knows what funds are available. Funds may be divided between hardware, software, and conferences or training. Periodic workshops are available for teachers focusing on computer and software skills. Most workshops do not discuss using computers within the classroom,

rather they are concerned with making teachers more comfortable at the computer and increasing their technical skills.

Table 9 lists some comments that led me to the development of the KPA's for Level 2. The KPA's from Level 2 of the SW-CMM are listed as well along with the resulting KPA's for the TI-CMM.

Table 9. Linking the data with the SW-CMM to devise the KPA's for Level 2, Emerging

Level 2
"We're completely networked; almost every class has Internet access." (School E)
"Think about the easy access they have to the Head, that's assisted by technology, and then I go online and I can see the things they're talking about in their conferences so it's brought us closer and if I have to I can send an email if I don't agree with something to say you know why don't you look at it this way too and sometimes I write directly to the student." (School B)
"Technology is very beneficial, it engages students, keeps them organized by formatting & presenting, and there's access to more information and now we can teach them how to make sense of that stuff. The students are proud of their work when they do it on a computer." (School E)
"We need a committee, and I'm trying to set up a (technology) committee." (School E)
"Tech. plan? Not really, but sort of ...and I guess we review it yearly. We want to establish one, though. It will look at a direction, and why we want to use technology and training." (School C)
"There's no software budget, well I guess the administrator has one, but if we want something we go to the administrator of the principal. But it hardly happens." (School E)
"I am the Ed. Tech Coordinator for the school, and I provide support. I have ¼ reduced load for this." (School E)
"(Technology gives) enormous opportunities given to students who wouldn't be able to express themselves (otherwise)." (School C)
"There's a lot of excitement about it around the school about technology." (School B)
"So it (technology)'s pretty exciting." (School D)
"We have two technicians and one technology integration specialist." (School A)
"I'm proud of my Web Design course. The approach was to get a high school class to act as web designers for elementary grades. It gave them a stewardship role and a project involving communication." (School E)
"Technology acceptance here is mixed...some teachers feel threatened, but generally they feel there is some allure in it, and we are making progress integrating it." (School E)
"Teachers don't document their use of technology...I don't think they even write it in a lesson plan or anything they just think this is a neat idea let's try it and see how it goes." (School E)
"... I don't think of computer science courses so much when I think of technology here, they're great courses, but we seem to talk about and put our efforts into how it (technology) is used in other classes." (School A)
"Using technology in other *classes* depends on the kid, and the teacher, but the problem here is it's not integrated I mean we're moving we're starting." (School D)
"We need to work on integrating computers in teaching and learning and we need more computers." (School E)
Are you the technology champion? "No. I mean obviously I'm the principal and so we set the tone because I make the budget decisions and the decision to wire the school in one fell swoop that was my

<table>
<tr><td colspan="2">decision." (School D)

"It's because they (teachers) haven't had the training so they say hey that's great but what does it do …How can I teach math?" (School D)

"…. typically what happens you go to a workshop someone shows you a new piece of software or whatever it is you go back to your school, you don't have it then a week goes by 2 weeks a month and then that goes there." (School D)

"Computers and the Internet make us think about how we teach and sometimes, what we teach." (School A)</td></tr>
<tr><td>SW-CMM Level 2 Repeatable
(TeraQuest, 2002)

At this level, basic management processes are established along with some documentation (e.g. costs, schedules). Consequently, it is possible to repeat previous successes. The focus is on project management.
KPA's
1. Requirements Management
2. Software Project Planning
3. Software Project Tracking and Oversight
4. Software Subcontract Management
5. Software Quality Assurance
6. Software Configuration Management

Move to next level by implementing common application development practices</td><td>TI-CMM Level 2 Emerging

KPA's
1. Interest/Awareness
2. Networking
3. Episodic Use

Move to next level by:
1. Developing technology committee for planning, establishing budgetary needs for future.
2. Developing faculty interest in technology.
3. Providing more curricular integration assistance, increased professional development opportunities for teachers.
4. Providing electronic communication system for students and staff.
5. Appointment of person responsible for technology use, and empower this person with budgetary control or decision-making ability.</td></tr>
</table>

Key Process Areas for Maturity Level 2: Emerging

The goals of each KPA of level 2 are described below. Once an organization has satisfied all of the goals listed here, it can be categorized as level 2 of the TI-CMM.

2.1 Interest/Awareness

Goal 2.1.1 Teachers are expressing interest in using technology in their classes, although not all are acting on this interest or feel they are capable of using technology.

Goal 2.1.2 Some teachers use technology, and activities are tied into the curriculum. The technology may still be used as a reward or to improve student interest and motivation, but it is also used to meet curricular goals.

Goal 2.1.3 The school's administration actively looks for ways to encourage technology use and is showing support for professional development activities.

2.2 Networking

Goal 2.2.1 Almost all classrooms and offices are networked.

Goal 2.2.2 The networked rooms have access to the Internet.

2.3 Episodic Use

Goal 2.3.1 Some subject teachers, other than computer teachers, use technology in their classes.

Goal 2.3.2 Teachers who use technology are satisfied with the outcomes.

Goal 2.3.3 Teachers who use technology would consider using it again and are actively looking for other technology activities.

2.4 Skills-based Professional Development

Goal 2.4.1 Professional development is provided to increase teachers' level of personal proficiency with the computer. Instruction on basic computer skills and applications are provided.

In order to move to the next level, a technology committee must be established whose mandate is to plan and budget for future technology needs. In addition, a technology "champion" has been identified to model and support technology use. The school has generated more interest among teachers for using technology by providing more curricular integration support and more professional development opportunities. Continued acquisition of hardware and software occurs to meet the needs of teachers and students, including an electronic mail and/or conferencing system.

At this level, technology does affect student learning and teachers are more thoughtful in the technology activities they select, trying to link them with their course curriculum, and not just use them as a classroom "extra" or reward for students. The school's administration acknowledges a need for additional human resources to support teachers in their use of technology, usually by assigning a computer or computer-savvy teacher a half-time position of technology integration specialist. Other outcomes for this level are listed in Table 10.

Table 10. Outcomes for Level 2

Student Learning • There is no formal assessment of technology activities • Teachers use informal assessment of technology activities in their classes. • Computer activities are not always selected randomly, and they usually have a direct relation to curriculum. • Computer activities generally fit in the upper right section of the Cognitive Process/Knowledge matrix. • Technology activities are considered to be an "add-on" or "reward".
Resources • There are active attempts to increase availability of resources to teachers.
Support • Part time integration support is provided by teachers, usually as another teacher with a reduced course load. • The technology plan includes hardware and software.
Professional Development • Some professional development activities occur, usually in the form of workshops. • Plans for increased professional development, considering technology needs and requests of teachers

Level 3 Defined

In the original CMM, the defined level occurs when management and employees are using a set of defined standards to accomplish a task. Standardization does not always apply to the tasks that teachers and students perform; however, it can apply to administrational practices and priorities, which will reflect on the resources available to teachers.

At this level, more computers and related devices are available within the school. Almost all offices and classes are networked and have Internet access. All offices have computers, and the library has computers for student or teacher use. Some classes may have computers in them, depending on whether the teacher has requested them, and some classes may even have clusters of computers. If a classroom does not have computers in it, then the teacher can take his or her class to the computer lab almost any day.

Teachers are anxious to use more computer activities in their courses, and they feel restricted by limited availability of computers in the school when they want them, as well as their own abilities to use computers within their subject. Most teachers are comfortable with basic word processing skills, emailing, and looking for information on the Internet. They want more professional development in this training and the administration tries to provide at least one workshop on pedagogical days and tries to provide funds for attending other computer seminars.

There is a technology "champion" who has supporters among teachers and administrators. This person either has budgetary control or influence among senior administrators to ensure that funds are provided for technology and plans are implemented. He or she is very persuasive and tenacious. This person provides the blueprint for technology plans, and is attuned to the computer requirements of other teachers and departments.

Most teachers and administrators see computer use in schools in a positive light, although they may not be able to articulate why and how it can be beneficial in a given subject area. They acknowledge that many students have computers at home, but they do not see this as a reason not to have computers at school; on the contrary, they see it as more reason to provide computers at school. They are thinking about how technology can benefit the teaching and learning processes beyond Internet research, word processing, and presentations.

Many of the school's constituents provide input into the technology plan, although it is the technology champion who ensures that the plan is carried out. The plan is a "living document" that is revised regularly, usually yearly. The plan ensures that it

has continual funding, that computers are upgraded according to some guideline, and provides funds for professional development and other human resources. The technology plan also includes pedagogical goals for student learning with technology. The committee may decide to use an existing framework such as the ISTE's National Education Technology Standard for Teachers and Students, or develop their own set of goals for computer literacy, information usage in the age of the Internet. These goals provide a guideline for computer and Internet use within each course.

The computer teacher or computer "champion" may have release time to provide support to other teachers trying to use computers in their classes. Generally, at this stage, this person is a teacher who is given release time to work with other teachers. How he or she assists various. He/she may visit classes, co-teach, or work one-on-one with other teachers to improve their computer skills or develop classroom projects. More technical support is available either by providing release time to a teacher or hiring a part-time technician or establishing more regular visits from the school board technician. Computer down time due to technical failures is becoming less of an obstacle that prevents teachers from using computers.

Some teachers still use activities at the lower left of the Cognitive Process/Knowledge grid, but many are experimenting with activities that would fit further to the right or lower on the grid. Student computer projects are evaluated and the computer has become a vital means for some teachers in designing and delivering instruction.

Having worked to attain this level, some organizations might choose to stop their growth at Level 3, as it seems to be a stable state. Given that this model is about

technology use, and technology is constantly evolving, no organization, including schools, can stop monitoring and testing new and potentially useful developments. By being too complacent and settling at Level 3, over time it would be possible to degrade back to Level 2. Table 11 shows comments from the data that, when considered together with the KPA's from the SW-CMM, lead to the development of the KPA's for this level of the TI-CMM.

Table 11. Linking the data with the SW-CMM to devise the KPA's for Level 3, Defined

Level 3
"We have a five year technology plan that is reviewed yearly." (School A)
"(Our IT Director) writes the plan and everyone agrees to it....It's funded by our operating budget." (School B)
"(Our IT Director) had a vision but because he was also at teacher he modeled a lot of what you can do with technology which was a big help to the other teachers."(School B)
"The (electronic) conferences are great and email too because teachers can answer emails at home, they're available more to the students, although I'm not sure all teachers would think that's great interfering on their weekends." (School B)
"I've created conference folders on (our electronic conferencing system) by dept and I'm not doing paper copies just drop them in the conferences." (School D)
"Teachers really have embraced the technology and are willing to put in a bit of extra time to learn, and if we took it away from them now they'd scream bloody murder."(School A)
"...for professional development (for technology), there has to be a variety of streams tailored to how comfortable (the teachers are with technology)." (School D)
"Professional development is still sort of informal, depending what I have time to push, but we have funds for it and offer workshops." (School A)
"It's a lot of extra work to learn and keep your skills up to date...you know I've taken evening courses on my own, not because I have to." (School F)
"You're (the student) not doing it just to make the teacher happy, it's real world stuff and so that is pretty much the trick now in integration." (School D)
"...as soon as everyone [the teachers] had a laptop a lot of admin tasks changed....teachers were indirectly being forced to apply technology and as they learned more they started to discover maybe it could be used in the classrooms." (School B)
"....and we have an Acceptable Use Agreement in general and a Responsible Use Agreement for laptop students...." (School A)

SW-CMM Level 3 Defined (TeraQuest, 2002)	**TI-CMM Level 3 Defined**
At this stage, all processes are documented and standardized. Projects use approved version of organization's standards, ensuring a higher ratio of project success. Move to the next level by taking quantitative control of projects. KPA's 1. Organization Process Focus 2. Organization Process Definition 3. Training Program 4. Integrated software Management 5. Software Product Engineering 6. Inter-group Coordination 7. Peer Reviews	KPA's 1. Technology Champion 2. Valuing of Technology 3. Technology Plan / Committee 4. Technology Integration 5. Access 6. Support 7. Curriculum Technology Matching 8. Electronic Communications 9. Responsible Computing **Move to next level by**: 1. Increased professional development opportunities for all teachers focusing more on curricular use, not only computer skills. 2. Increased hardware/software purchasing to meet requests of teachers. 3. Teachers use technology regularly and repeatedly.

Key Process Areas for Maturity Level 3: Defined

Because of the increased resources, both human and physical, there are more KPA's and goals for each at this level.

3.1 Technology Champion

Goal 3.1.1 The technology champion works with teachers and suggests technology activities.

Goal 3.1.2 This person is a senior administrator or is regularly consulted by the senior administration.

Goal 3.1.3 The technology champion has a budget to manage or direct input to the school's technology budget.

3.2 Valuing of Technology

Goal 3.2.1 The faculty and administration of the school believe that technology plays a beneficial role in the teaching and learning processes.

Goal 3.2.1 Teachers can articulate what areas of their courses are or could be improved by technology.

Goal 3.2.2 The administration takes measures to promote the use of technology in the school.

Goal 3.2.3 A large majority of teachers are interested in and supportive of technology.

3.3 Technology Planning

Goal 3.3.1 A committee exists that either devises or approves a technology plan.

Goal 3.3.2 There is a long-term technology plan that is updated yearly.

Goal 3.3.3 The technology plan includes financial, hardware, software, networking, and personnel resources.

Goal 3.3.4 The technology plan includes plans for a variety of professional development activities for the current year and in the future.

Goal 3.3.5 The technology plan includes pedagogical goals for technology use or references an existing document.

3.4 Technology Integration

Goal 3.4.1 A majority of teachers use technology some of the time in their classes.

Goal 3.4.2 Teachers choose authentic learning activities that support their curriculum. Although they are aware of these advantages, they do not use technology activities only as a reward or only to gain student interest.

Goal 3.4.3 Teachers use technology activities that may fit on any place of the cognitive process/knowledge grid.

3.5 Access

Goal 3.5.1 Computers are available in adequate numbers for teacher use.

Goal 3.5.2 Internet access is available throughout the school.

Goal 3.5.3 Computers are available for student use during class time and during spare time at school.

Goal 3.5.4 Peripheral devices are available for teacher and student use. These may include scanners, digital cameras, video cameras, electronic white boards, or data input probes, etc. The devices available depend on the teachers use and requests.

3.6 Support

Goal 3.6.1 A technician is on-site regularly and makes timely repairs to equipment. The number of technicians depends on the amount of equipment available at the school. This position may be part time, but the goal is that no equipment is unused because it can't be repaired.

Goal 3.6.2 A curricular integration specialist is available to support teachers interested in using technology. This position may be part-time, but the goal is that teachers have support when they request it.

3.7 Curriculum/Technology matching

Goal 3.7.1 Teachers use technology for activities that enhance the teaching and learning process, rather than using it solely as a reward or student motivator.

Goal 3.7.2 Teachers look for instructional software that is directly related to their course topics.

Goal 3.7.3 Teachers use technology for longer projects, not just for single class activities.

3.8 Electronic Communications

Goal 3.8.1 A means of communicating electronically exists (for example, an email system such as FirstClass.)

Goal 3.8.2 Teachers and students use this messaging system to communicate with each other.

3.9 Responsible Computing

Goal 3.9.1 The school has a document outlining responsible and acceptable use of computing and electronic messaging facilities.

Goal 3.9.2 This document is made available to staff and students.

To move to level 4, there may have to be increased hardware and software acquisition, but as long as the availability satisfies teachers' and students' demands, it

may not be necessary to acquire more hardware. Some schools may feel that teachers and students should have access to a computer when desired, which may or may not mean implementing a one-to-one laptop programme, as some schools have done. Access may be accomplished by providing multiple machines in offices, and additional computer labs, or by providing more free periods in the computer labs. Continuing professional development focuses on how to use computers in classes to improve student learning, and does not focus only on teachers' computer skills. Teachers are encouraged to use computers regularly, and some have favourite technology activities that they use and improve upon from year to year.

At this level, increased resources and professional development help to improve student learning with technology and teachers' acceptance of technology. Table 12 lists all outcomes for this level.

Table 12. Outcomes for Level 3 Defined

Student Learning • Technology activities are selected by teachers to address specific areas of the curriculum. • Technology activities are considered valuable as a learning activity. • Technology activities are evaluated and modified based on their impact on student learning outcomes • Pedagogical uses of technology formally identified by teachers for individual courses. Some technology projects may become part of the course curricula. • Teachers' focus is on valid use of technology, not just access to resources or as supplemental activities.
Resources • There is broad access to technology • Funds are available for professional development • The network and electronic communications are used to increase and improve communication among teachers and students.
Support • Professional development takes occurs regularly in several formats • Curricular support is available • Technical support is available within the institution
Organization • Organizational vision for technology exists and is used to generate the technology plan • Technology plan includes overall pedagogical goals for using computers and the Internet.

Level 4 Managed

In the original CMM, this level is called the *Managed* level because quantitative and qualitative measurements of job processes are taken and used to improve activities. At this level in the TI-CMM, measurements and documentation can be taken and used individually by teachers, as well as collectively by the technology director to improve the affect of technology on learning outcomes. Evaluations are based on the pedagogical goals for technology as outlined in the technology plan.

The technology champion still exists but he/she is actually implementing plans instead of developing plans. Teachers and students have as many resources as they wish, whether it is a one-to-one laptop model, multiple computers in the classroom, or another model that meets their collective requirements. Equipment is located where it is needed but at the same time, there isn't an excess of equipment.

Technology use is supported by the administration and a long-term technology plan exists that is modified on a yearly basis. It is expected that funds are required to sustain this plan on a yearly basis. The plan includes hardware rotation, software, infrastructure (network and servers), and professional development.

The plan for professional development includes not just funding, but more precise plans for teacher training that includes when, where, how and what. Needs assessments are conducted regularly to determine these professional development requirements. .Multiple methods of professional development are used including workshops on pedagogical days, peer-coaching, self-training resources, and funds for workshops, conferences, and seminars.

Technicians are available on site and there is at least one integration support specialist (possibly a teacher) to assist teachers devising and delivering computer activities.

Teachers' attitudes toward technology are positive and they do not feel threatened by it. Some teachers are more comfortable using computers than others, but all teachers use computers occasionally and many use technology in their classes regularly, although not exclusively. Most teachers use technology activities that occur in the lower or right portion of the Cognitive Process/Knowledge matrix. Teachers plan for technology

lessons as an integral part of their courses. In fact, technology has become so embedded in their practice that without it, they would not be able to deliver some lessons.

Teachers are familiar with the nuances of evaluating technology projects and may use rubrics, portfolios, or other assessment tools for computer projects. As a new phenomenon in schools, teachers will not have had training or may not be familiar with how to evaluate electronic assignments. At this level, teachers have had more experience and/or training in assessment of or with computers.

Table 13 includes comments and KPA's from the SW-CMM that, when merged, helped to develop the KPA's for this level.

Table 13. Linking the data with the SW-CMM to devise the KPA's for Level 4 Managed

<table>
<tr><td colspan="2">Level 4
"We still haven't got computers to every kid." (School B)

"We're starting a one-to-one laptop programme next year for Gr 7 & 8 expanding through 9,10,11." (School A)

"Every teacher has been assigned his own laptop computer." (School A)

"...maintain network efficiency, hardware as well...I'm constantly upgrading the network" (School B)

"I just hired 10 brand new teachers...the teachers ... were hired to teach more than 1 subject and they are all comfortable with technology." (School D)

"Now that we are using laptops here, you have to think about that when hiring teachers or does it make our teachers more attractive to other schools? I think so...."(School A)

"We're hiring 3 new staff this year, so that may make a difference in how computers are used." (School E)

Question: Is technology well accepted at your school? "Not even a question here. When you work here you get a laptop to take home it's basically yours. I'd say that some use it more than others of course, that's just people and you can't expect some of the older teachers to do the same things as some of the others." (School B)

"There's a lot of access to technology here....I don't think the teachers here would complain that they don't have what they need or even what they want." (School A)</td></tr>
<tr><td>SW- CMM Level 4 Managed
(TeraQuest, 2002)

This has been called a quantitative level, as detailed measures of processes and product quality are collected. This data is used to establish controls to ensure quality & performance.

Move to the next level by continuously improving practices.

KPA's
1. Quantitative Process Management
2. Software Quality Management</td><td>TI-CMM Level 4 Managed

KPA's
1. Embedded Technology
2. Documentation of Use
3. Ubiquitous Access
4. Supportive Hiring Practices
5. Quality Management
6. Quantitative Process Management
7. Professional Development

Move to next level by:
1. Evaluating the overall technology programme and individual technology activities.</td></tr>
</table>

Key Process Areas for Maturity Level 4: Managed

At this level, the school is building on teachers' knowledge and experience gained from the previous level. Hence, a greater investment in new teachers may be necessary so they are comfortable with the technology use. Technology use is still vital in the classroom, although it has become more transparent. Teachers and students no longer emphasize technology; the technology exists but their focus is on learning. The goals for each KPA at this level are listed below.

4.1 Embedded Technology

Technology "integration" implies it is an addition to the course and this addition may be contrived. Embedded technology is used naturally and normally as a part of the course. Technology is not used exclusively, although it is integral to delivering the course material.

Goal 4.1.1 When used, technology does not become the focus of the students' or teacher's attention. The focus remains on the course topic.

Goal 4.1.2 Teachers spend very little or no time giving instruction on technology. Computer teachers and technology support teachers are the exception.

Goal 4.1.3 Some course topics cannot be taught without the use of technology.

Goal 4.1.4 Technology failure does not interrupt the class. The equipment, supporting networks and peripherals are reliable and robust. This

can be measured by the amount of downtime and repairs required.

4.2 Documentation of Technology Use

Goal 4.2.1 Teachers create lesson plans for technology, including objectives, process, and evaluation. Just as teachers use lesson plans, they keep a record of what technology is used and determine the learning objectives that are to be accomplished with the technology.

Goal 4.2.2 Teachers can state which technology activities helped to achieve their learning goals and which did not. They adjust their teaching plans accordingly.

4.3 Ubiquitous Access

Goal 4.3.1 Teachers and students have access to the technology they require to deliver their curricula.

Practices required to meet this goal will vary from school to school. In some schools, this may mean every classroom has Internet access. Some schools may opt for a one-to-one laptop programme for students. Other schools may decide to use clusters of several computers per classroom or multiple computer labs to meet the demands of teachers.

Goal 4.3.2 Teacher requests for technology are considered when modifying technology plans.

Goal 4.3.3 Technology is used in and out of the classroom for pedagogical purposes and administrative tasks.

Goal 4.3.4 Students use technology outside of classes for activities that support their class work.

4.4 Supportive hiring practices

Hiring practices will have to include selection criteria to ensure that candidates can function in a technology-infused classroom. Not all teachers will be comfortable in such an environment, and teachers who are effective at using technology may be in greater demand.

Goal 4.4.1 The Technology Director is a member of the interviewing team.

Goal 4.4.2 Evaluation criteria include: i) ability to use some of the school's existing technology and ii) the willingness and aptitude for learning new technology.

4.5 Quality management

Quality management ensures that technology is being used to authentically support curricular goals. Teachers may feel pressured to use the available technology because "it's there" or they may use it for activities that do not support their teaching and learning objectives.

Goal 4.5.1 Teachers record lesson plans for technology use including learning goals, methods, outcomes, and evaluation.

4.6 Quantitative process management

Quantitative process management ensures that a variety of technology activities occur within the school. For example, if students are assigned PowerPoint

presentation activities for each course, then they will soon tire of using this technology, and the extra value it brings to the course will be diminished.

Goal 4.6.1 The technology director tracks the type of technology activities used at each grade level.

Goal 4.6.2 The technology director encourages a variety of technology activities across each grade level.

Goal 4.6.3 The technology director encourages a spiraling curricula of technology skills vertically across grade levels.

4.7 Curriculum-based Professional Development

Goal 4.7.1 A variety of professional development activities are offered. These may include external workshops, in-service training, peer mentoring, one-to-one training with a technology specialist, on-line courses, etc.

Goal 4.7.2 Focus of the professional development is on embedding technology within the curriculum, not just computer skills.

Goal 4.7.3 Teachers are offered professional development activities that are subject specific.

Goal 4.7.4 The technology plan includes funds for professional development.

Goal 4.7.5 An inventory of teachers' technology skills occurs every year.

Goal 4.7.6 Professional development activities are planned based on the skills inventory.

Goal 4.7.7 A long-term professional development plan exists.

Goal 4.7.8 Professional development is an organizational and individual responsibility. Teachers are compensated financially or with release time for their efforts.

4.8 Evaluation

Goal 4.8.1 Teachers use assessment methods such as rubrics and portfolios to evaluate student work done using computers.

Goal 4.8.2 Teachers are aware of issues facing education in the electronic age including plagiarism, information authenticity, and verification of web sites.

Goal 4.8.3 Computer and Internet activities can be evaluated based on the pedagogical goals outlined in the technology plan.

The emphasis in level 5 is on managing constant change. To reach this level the school develops methods to evaluate their technology programme and technology activities to ensure they are meeting the goals of improving and enhancing student learning. All of the pedagogical, professional development, and acquisition goals in the technology plan have been met.

At level 4, technology is truly embedded within the curriculum. It is used often and it is an accepted medium for learning. I prefer to use the term "medium for learning" here, rather than the frequently cited "tool" analogy, because a) a computer can be more powerful than a standard classroom tool such as textbooks, notebooks, overhead projectors, b) it takes a great deal of time, effort, and resources to reach this stage where it is an integral and accepted part of the classroom, and c) there are a broad and varied range of learning opportunities available through computers and the Internet. Also at

level 4, there is more documentation and assessment of technology activities to ensure its use is closely linked to student learning and curricular objectives.

Table 14 Outcomes for Level 4, Managed

Student Learning • Technology is embedded into the curriculum. • Learning outcomes for lessons using technology are formally identified, documented, and evaluated. • Students are demonstrating all of the National Education Technology Standards through a variety of technology projects in their classes. (The school may prefer to use another set of standards or develop their own.) • Technology activities classified in the lower or right portion of the Cognitive Process/Knowledge matrix.
Resources • Students use resources regularly at school and at home • Increased availability of resources to teachers and students
Support • Technical support is available on-site. Repairs and technical requests are completed in a timely manner. • Curricular integration support continues
Professional Development • A variety of professional development formats are available. • Teachers are meeting all of the criteria outlined in the National Education Technology Standards for teachers.

Level 5 Optimized

The optimized level sees continuous process improvement where the process is teaching with technology. At this stage, the school actively seeks and encourages pilot projects for new innovations. At this stage, technology is such an integral part of the school that it is no longer considered to be a novelty. Teachers and students may even take it for granted. It may be described as truly "ubiquitous". Computer and network resources are available almost everywhere, if teachers and students wish to use them.

The technology plan is a "living" document; it is comprehensive, applied, and modified regularly. Because technology is easily accepted and teachers adapt it to their

curriculum, the role of the IT Director is less critical and he/she spends more time researching new technologies and their possible use within schools. Professional development is an accepted component of the teaching profession. Teachers may take advantage of a number of types of training from peer coaching, individual study, workshops, or conferences, as needed.

Technical support is readily available, however seems to be an invisible function and it is rarely mentioned by teachers because technical problems are rare and technical staff solve problems quickly when they do occur.

Teachers devise activities from all areas of the Cognitive Process/Knowledge matrix, as required by their curriculum, but tend to devise activities that would fit in the bottom or right sections of the grid. Teachers who are newly hired in a school at Level 5 are either experienced with using computers in their classes and/or they are willing to learn how to use technology for teaching. Unfortunately, this may make the hiring process difficult.

At this level, change is more easily accepted and expected by all school constituents. The administration provides resources for facilitating this change. Comments from the data that contributed to the development of the KPA's for this level are listed in table 15.

Table 15. Linking the data with the SW-CMM to devise the KPA's for Level 5

<table>
<tr><td colspan="2">Level 5
"...teachers and students use technology constantly, it is ubiquitous" (School B)

"It (technology integration) sort of takes care of itself, but we are always reevaluating....here we have continuous integration." (School B)

"Apple introduced this thing that looked like a Fisher Price toy and it had a handle and it was colourful and quite durable, the Ibook and then we looked at that and it was affordable, quite reasonable so we thought maybe we could work with it....it seemed feasible" (School B)

"(The) environment here is of learners – teachers and students both." (School B)

"Well definitely (we're proud of) our teachers. To see them learn and change....and it can really revitalize the career of someone who's been teaching 30 years and they get excited again and they've all worked hard and embraced it....to see faculty renew themselves with technology is great!" (School B)

"We hadn't really evaluated what we had done." (School B)</td></tr>
<tr><td>SW-CMM Level 5 Optimized
(TeraQuest, 2002)
This level focuses on change management and continuous process improvement. Innovative projects are encouraged and piloted. Feedback from processes allows for continuous innovation.

KPA's
1. Defect Prevention
2 Technology Change Management
3. Process Change Management</td><td>TI-CMM Level 5 Optimized
This level focuses on change management, researching innovations for education and introducing these innovations to the school.

KPA's
1. Technology Change Management
2. Curricular Change Management</td></tr>
</table>

Key Process Areas for Maturity Level 5: Optimized

The key process areas for level 5 focus on change management, specifically new teaching methods resulting from the use of technology, as well as incorporating new technology into the classroom. Ideally these new methods are evaluated and then accepted or rejected based on whether or not they improve student learning outcomes.

5.1 Curricular change management

In many schools, the technology mantra is that the curriculum should drive technology. As technology becomes more embedded within education, more ubiquitous, and transparent, it follows that the curriculum itself may change because of technology. The purpose of curricular change management is to identify areas of the curricula which can be adapted to technology in a manner such that the teaching and learning processes are improved. Examples include the use of electronic conferencing systems to deliver material and establish topic discussions. Real-time Internet resources offer new ways of delivering timely topic material to students. Certainly the use of technology encourages more cross-curricular activities where, for example, English, history and art can collaborate in a single project.

Goal 5.1.1 A list of technology activities for each grade and subject is compiled yearly.

Goal 5.1.2 The list of technology activities is reviewed for too may redundancies, and, in consultation with teachers, modified to eliminate some duplicate technology activities.

Goal 5.1.3 Appropriate technologies are transferred into the normal practice of the school.

Goal 5.1.4 Cross-curricular projects are planned and implemented.

5.2 Technology change management

The purpose of technology change management is to identify new technologies that would be feasible and useful in an educational setting. Not every new technology is beneficial in an educational environment. Once identified, these technologies are transferred to the school in a non-disruptive manner.

Goal 5.2.1 New technologies are researched and proposed by the technology director and evaluated by appropriate subject teachers.

Goal 5.2.2 Incorporation of technology changes are planned.

Goal 5.2.3 Funds are available to support the research and implementation of new technologies.

At this level, the outcomes focus on continuous improvement and adoption of innovations. These outcomes are listed in Table 16.

Table 16 Outcomes for Level 5 Optimized

Student Learning • Effectiveness of technology for teaching and learning evaluated regularly • Pedagogical plans are redeveloped to reflect the changing environment and teachers' and students' technology needs
Resources • Formal process for evaluating resources as they meet goals of the organization as a learning institution • The budget continually funds technology maintenance and improvement. • There are active attempts to increase the type of resources to teachers.
Support • Learning outcomes are the principal driving force for all technology changes and acquisitions.
Professional Development • Teachers accept that technology change is inevitable and on-going professional development is required.

Summary

Summary diagrams are provided for the reader to acquire an overview of the entire TI-CMM model. Table 17 summarizes some of the characteristics of schools at each level in terms of technology plan and resources, Table 18 summarizes the Key Process Areas of the TI-CMM, and Table 19 provides a synopsis of the tasks required to move up a level.

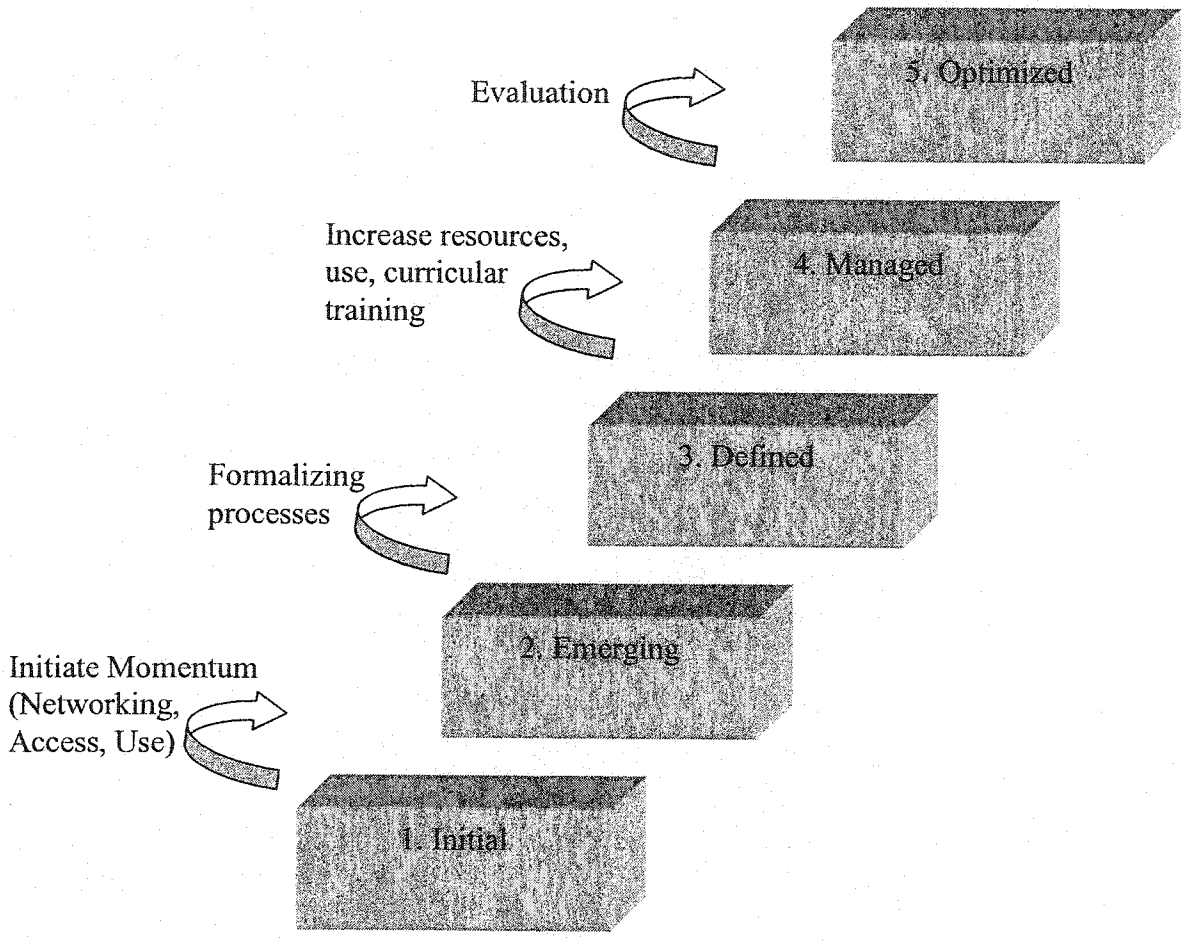
Table 17. Summary of the description of levels of the TI-CMM

	Technology Plan	**Role of the Technology Champion**	**Physical Resources**	**Human Resources (support)**	**Professional Development**	**Frequency of Use**	**Type of use**
1. Initial	No formal plan	No one person has this role	1 or 2 computer labs	occasional visits by technician; computer teacher	Infrequent	Ad-hoc, but infrequent	Random uses: eg. educational software, games for reward
2. Emerging	Developed on a year to year basis	One person is acknowledged as "champion"; but may not have enough influence to affect change	1 or 2 computer labs; computers may be in the library, some classes	Computers more regularly checked by technician; computer teacher may help others if they ask	Teachers show more interest; may be more workshops offered	Teachers bring their classes to the lab or library more often	May require student assignments to be word processed; still bottom left of CP/Knowledge matrix
3. Defined	There is a long term plan	Is senior administrator or has influence and budgetary control	In addition to labs, all offices and many classrooms have computers & network access	Technical support available part time; computer teacher has release time to work with others on integration activities	Workshops are offered regularly; these workshops tend to be skill based	Computer labs are often booked, teachers would like more use frustrated by lack of access	Seen positively, teachers experiment with new activities, moving toward the middle of the CP/Knowledge matrix
4. Managed	Long term plan reviewed yearly	Works to implement plan, not just make plans	Available as teachers & students require; may be one-to-one model	Technical support available on site daily.	Precise plans for pd in terms of skills and classroom activities	Most teachers use it regularly but not exclusively	Activities from all cells in the CP/Knowledge matrix; some activities couldn't be done without computers
5. Optimized	Long term plan reviewed yearly	This role less crucial; spends time researching new technologies for education	Available as teachers & students require; may be one-to-one	Technical support "invisible" for the most part because they do their job so well	Accepted as a part of the profession; various types of pd available on regular basis	All teachers use it regularly, but not exclusively; it is "ubiquitous"	Truly integrated, teachers don't devise special computer projects

Table 18. Key Process Areas of the TI-CMM

1. Initial	2. Emerging	3. Defined	4. Managed	5. Optimized
No Key Process Areas	Interest / Awareness	Technology Champion	Embedded Technology	Curricular Change Management
	Networking	Valuing of Technology	Documentation of Use	Technology Change Management
	Episodic Use	Technology Plan / Committee	Ubiquitous access	
	Skills-based Professional Development	Technology Integration	Supportive Hiring Practices	
		Access	Quality Management	
		Support	Quantitative Process Management	
		Curriculum – Technology Matching	Curriculum-based Professional Development	
		Electronic Communications	Evaluation	
		Responsible Computing		

Figure 1. *Synopsis of tasks required to move to the next level*



Classifying the Six Cases

In order to apply the TI-CMM, I have classified each school. To be classified at a level beyond the initial level, a school must satisfy all of the goals of that level. For example, if a school has met all the goals at level 3, but only some of the goals of level 4, then they are classified at level 3.

School A, my own school, is currently at Level 3. While this school I is successfully implementing many of the Key Process Areas of level 4, the qualitative and quantitative management goals are not being met.

School B, one of the laptop schools in the study, is very close to receiving a level 4 rating. Although this school meets some of the Key Process Areas of Level 4, it does not satisfy them all, and is therefore classified at Level 3.

Although School C shows some characteristics of Level 3, they do not meet all the goals at this level. Consequently, they are a Level 2 school, but very close to receiving a level 3 rating. The main factors that keep them at level 2 is the administration's self-proclaimed "ambiguous" attitude toward technology, and the lack of a comprehensive and renewable technology plan.

School D is at Level 2, although it is has met some of the goals of level 3. By formalizing their technology plan, increasing technical and integration support, and encouraging more teacher use, they may be classified at Level 3 in a few years.

School E is classified as newly arrived at Level 2 by virtue of their plans to immediately create a technology committee, although the senior administrators did not seem to be encouraging a lot of technology integration. The teachers themselves showed

more interest, although there is still a need for professional development and additional hardware and support resources.

Based on my interviews, School F is at Level 1. There was very little use of technology outside of the computer studies courses, and technology use wasn't the highest priority of the administration. There were difficulties with maintenance and teachers' attitude toward using computers in their classes.

None of the schools in this study represented a Level 5 rating, although they all contributed to the development of the Key Process Areas for level 5 by identifying their plans for future years.

Limitations of the Study

My position of IT coordinator at one of the participating schools may have affected some of the responses from this school, as some teacher comments were directed at specific issues they felt I could resolve within the school.

The response rate to the surveys was low in most of the schools. This was not surprising, and I do not attribute this to lack of interest in technology, but rather to teachers' busy schedules, and to the lack of an incentive or reason for them to return the surveys. A larger response rate may have generated different results for each school's analysis, and it is not possible to state that these views are representative of the teaching faculty of the schools. Furthermore, it was not possible to qualitatively differentiate each school in terms of their technology use, which made it impossible to organize the schools based on the levels of a generic CMM framework.

Only a few schools were studied in the process of developing this TI-maturity model. A generally acceptable TI-maturity model would have to be generated from the data of many and more varied schools. More data would have generated a more detailed description for each level of the model.

Public schools may feel that the TI-CMM is applicable only to private schools with larger operating budgets. Certainly it may be easier for these schools to acquire hardware and software, but it is possible to apply the TI-CMM practices without making a financial investment. Also, meeting computing needs of teachers and students does not mean that every person must have his or her own computer. These needs may be met by providing "mini-labs" or situating computers in classrooms instead of labs, or relocating a computer lab to an area of the school that is easier to access or more centrally located.

As one principal of a public school said, "If you think it's important (technology in schools), then you just do it…you find a way and work through or around the budgets."

The TI-capability maturity model was developed largely from the data collected, although having immersed myself in this data, it is difficult for me to separate what proportion was developed through the data only and that influenced by my own experience and ideas about technology in schools. This is characteristic of a qualitative review. It would not have been possible to develop this model without studying each of these schools.

Chapter 5 Conclusion

This study developed a Technology Integration Capability Maturity Model for K-12 schools' use of computers and technologies. While no model can perfectly represent the complex system of an educational institution as it adopts new technology, the TI-CMM is a useful model as it provides precise goals and guidelines for making improvements. It is grounded within research from educators who have different principles and output than commercial organizations. The TI-CMM is an evaluation tool, a guideline for planning, and for measuring successful technology implementation. The TI-CMM appraises the school's current use of technology and its readiness to move to a higher level of use. By applying the practices, a school should be able to improve their technology use for teaching and learning. Such a model is appropriate for any organization developing the optimum use of an innovation.

The collected data generated additional noteworthy findings, including the vital role the technology "champion" plays in schools. In the SW-CMM, and the Human Resources CMM, too much reliance on an individual person is not desirable within an organization, earning the organization a level 1 rating. This is also reflected in the Level 1 of the TI-CMM as it is reliant on individual teachers to encourage technology use. But, promoting an innovation within a culture that is typically reticent to change requires a person appropriately placed within the administrative structure and with personality traits that allow him or her to effect change. So the reliance on an individual becomes an important factor at the middle levels of the TI-CMM. Not surprisingly, if the administration does not have a supportive attitude toward technology, this may affect the attitude and behaviour of the teachers toward computer use, of only by virtue of resources

not being allocated for technology.

Five of the six schools in this study had some form of a technology plan, even if it came from the School Board, but none of them had detailed plans for professional development. There was no discussion of needs assessments, the format of potential training, or the desired outcomes. If professional development was mentioned at all, it was in terms of funding.

A second and critical component missing from technology plans were overall pedagogical goals for implementing technology. Pedagogical goals were not discussed often by IT Directors or Principals, although this may have been a result of the design of the data collection instruments. Most educators agreed that it could be useful, but they were imprecise when listing the advantages of technology in the classroom. Technology goals will help to direct their efforts and provide a benchmark for measuring progress. These goals could be prepared by teachers and administration themselves, or adopted from an existing document such as the National Education Technology Standards for Teachers and Students (see Appendices H and I).

Finally, the Cognitive Processes/Knowledge matrix is a useful framework for developing any learning activity and it is particularly useful when teachers are developing new computer activities, which is an area new to many teachers. This matrix can help teachers identify the outcomes of their computer activities and appropriate assessment tools for these activities.

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Appendix A Permission letter for Principal of School

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Dear **Principal**:

I am a graduate student in Educational Technology at Concordia University, and I am conducting a study on how schools develop technology plans and use computer and Internet technologies. I am wondering if your school would participate in my study. Participation is completely voluntary, and you or your teachers may withdraw at anytime.

This research involves three components. Firstly, I would send a questionnaire to each of your teaching faculty. For a second source of data, I would like to interview the technology coordinator of your school regarding the type of technology you are using to give a context for the teachers' replies. Finally, I would request 20 minutes of your time for a short interview about the technology planning process in your school.

The identity of your school and faculty will be kept confidential. There would be no disruption to your classes or schedule, and I would require only two or three visits to your school.

In exchange for your participation, I will summarize and make the collective results of the teacher surveys from your school available to you.

The data collection would occur before mid-February. If you would agree to allow me to collect data from your faculty, please contact me through one of the addresses below.

Thank you,

Brenda Montgomery
Graduate Student
Educational Technology
Concordia University

Telephone: 457-0359
Email: **bl_montg@education.concordia.ca**

Appendix B Consent Letter

Research Project: Developing a Technology Integration Capability Maturity Model for K-12 Schools

Researcher: Brenda Montgomery
Graduate Student, Educational Technology
Concordia University

The purpose of this project is to better understand how K-12 schools plan for and implement computer and related technologies for teaching and learning. This information will be used to develop a Technology Integration Capability Maturity Model.

Participation in the study is voluntary. Participants in this research will be requested to fill in some surveys and participate in interviews. If you are being interviewed, you are free to stop the interview at any time. If you wish to have your survey removed from the study, you may contact the researcher (via the liaison person at your school), and your copy will be returned to you or destroyed.

There are no risks to participating and the information you provide will be used for educational research use only. Interviews will be tape recorded for transcription later. All tapes, transcription notes, and results will be kept in a secure location where no one, other than the researcher has access.

If the researcher wishes to use one of your quotations from this interview in the final thesis, she will contact you for permission beforehand, and your name will not be disclosed in the thesis.

I agree to participate in this study conducted by Brenda Montgomery. I have read the information above. I understand that all information will be kept confidential and that I may withdraw from the study at any time.

I understand that if I am quoted in the final thesis, then my name will not be used, and the researcher will contact me for permission before using my quotation.

Participant's Name: _____

Participant's Signature: _____

School: _____

Date: _____

Appendix C Cover letter for Teacher Questionnaire

Dear Teacher,

I am conducting a study about technology implementation in K-12 schools, which involves gathering information regarding teachers' attitudes toward the technology and examples of actual classroom use of technology. Your school has agreed to be part of the study.

The following survey will assist me in this study. It will take approximately 15 minutes of your time. The first section is the Technology Implementation Questionnaire developed by the Centre for the Study of Learning and Performance at Concordia University. The second section asks you about specific technology activities you may use with your students.

All information will be kept completely confidential and results from individual surveys will not be shared with anyone. The collective results will be published in a report at Concordia and will be made available to your Principal and any others who request the results.

If you wish to receive the results of the study electronically, please fill in your email address below and return it with your completed questionnaire.

Participation is completely voluntary and it will be very beneficial in examining the link between technology planning and classroom use. Please mark all of your responses on the questionnaire.

Please return the completed questionnaires to xxxxxxxx.

Thank you for your participation.

Brenda Montgomery
Graduate Student, Educational Technology
Concordia University

I am interested in receiving the results of the study by email.

Email address: _____

Appendix D Cover Letter for Teacher Questionnaire at School A

Dear Teacher,

In requirement for my Master's degree, I am conducting a study about technology implementation in K-12 schools, which involves gathering information regarding teachers' attitudes toward the technology and examples of actual classroom use of technology.

The following survey will assist me in this study. It will take approximately 15 minutes of your time. The first section is the Technology Implementation Questionnaire developed by the Centre for the Study of Learning and Performance at Concordia University. The second section asks you about specific technology activities you may use with your students.

This information is being collected to assist me in completing my thesis. The collective results of the teacher questionnaires will be available for anyone to examine, it will not be used to directly influence any activity here at Selwyn House. In fact, Selwyn House is only one of several schools participating in the study.

All information will be kept completely confidential and results from individual surveys will not be shared with anyone. The collective results will be published in a report at Concordia and will be made available to those who request the results.

If you wish to receive the results of the study electronically, please fill in your email address below and return it to my mailbox with your completed questionnaire.

Thank you for your participation.

Brenda

I am interested in receiving the results of the study by email.

Email address: _____

Appendix E Administrator Interview Protocol

Administrator Interview Protocol
TI-CMM Project

School: _____ **Date:** _____

Place: _____ **Interviewer:** _____

Participant:_____ **Position of participant:** _____

Welcome
Thank participant for taking the time and tell him/her that you welcome his insights into technology use in schools. Explain that this interview should take approximately 20 minutes. Ask permission to tape record the entire interview. Take short notes of very interesting points to reference later. Test tape recorder.

Purpose of the Study
- to collect information about technology plans, to explore how computers and the Internet are being used in school, collect examples of best practices to develop a model of technology planning in schools

Sign Consent Agreement and Assure Confidentiality
- start tape recorder, make note of important points to examine on this form

Questions

1. How does your school plan and budget for technology?
   Probes: long term technology plan.

2. Do you have a formal technology plan that I could examine?
   - just want to see the types of things you consider, how far in advance you are able to plan

3. Who makes technology acquisition & planning decisions?

4. What are your short term and long term plans for technology at your school?

5. What aspect of technology at your school are you particularly proud of?

6. What aspect of technology at your school do you think needs improvement?

7. How do you measure or determine effective use of technology at your school? Is there a feedback process for projects you think are worthwhile and those that aren't?

8. Do you influence how technology is used at the school or encourage its use?
- is there a "champion" for technology at the school?

9. Are there policies for technology use?

10. Are there objectives of goals for technology use?

11. In general, does the curriculum support technology use?

12. Are there any guidelines for teachers using technology?
Probes: documentation process

13. How does your school provide technology professional development for teachers?

14. Do you feel technology is well accepted at your school or are teachers hesitant to use it?

15. Do you receive a lot of feedback from teachers about the technology at the school?

Appendix F Technology Coordinator Interview Protocol

Technology Coordinator Interview Protocol
TI-CMM Project

School: _____ **Date:** _____

Place: _____ **Interviewer:** _____

Participant:_____ **Position of participant:** _____

Welcome
Thank participant for taking the time and tell him/her that you welcome his insights into technology use in schools. Explain that this interview should take approximately 45 minutes. Ask permission to tape record the entire interview. Take short notes of very interesting points to reference later. Test tape recorder.

Purpose of the Study
- to collect information about technology plans, to explore how computers and the Internet are being used in school, collect examples of best practices to develop a model of technology planning in schools

Sign Consent Agreement and Assure Confidentiality

Support
Is there a person to provide technical support for teachers on site? Yes No
If yes, could you explain this job.
(eg how many people, is it full time, do they have other responsibilities?)

1. Is someone available to provide curriculum integration support for teachers?
   Yes No
   If yes, could you explain this job.
   (eg how many people, is it full time, do they have other responsibilities?)

2. If a teacher wishes to use his/her own computer for teaching purposes, would you provide support and software?

Infrastructure

3. Is the school networked? Yes No

   If yes, to what extent? (ie, how many rooms and offices are networked?)_____

4. Does the school have Internet access? Yes No

   If yes,

   a. How are you connected? How fast is the access? _____

   b. In how many classes and offices is it available? _____

   c. Is it available in other parts of the school? _____

5. Do you use servers in the school? If so, how many and what are their purpose?

Technology Planning

6. Does your school have a formal technology plan? Yes
   No

   Who is involved in developing and/or renewing your technology plan?

   a . What is the length of this plan, in years? _____

   b. Does this plan include hardware? _____

   c. Does this plan include software? _____

   d. Does this plan include servers? _____

   e. Does this plan include networking? _____

f. How often do you renew your technology plan? _____

g. How often to you upgrade or renew your computers? _____

h. Who is involved in developing and/or renewing your technology plan?

7. How is technology funded? Who makes the technology budgets?

8. Do you have copies of current or old technology plans that I could use for my data analysis? They will be kept confidential.

9. What are your short and long term plans for technology at your school?

Use of Technology

1. What other technology is available in your school that your teachers & students use?
   eg – networking, are all computers used regularly, Internet access

2. What is your "philosophy" about technology in schools? How and why is it advantageous and what are the benefits?

3. What software is available at your school? If teachers want a software title can they get it & how?

4. What aspect of technology at your school are you particularly proud of?

5. What aspect of technology at your school do you think needs improvement?

6. How does your school provide technology professional development for teachers?

7. Are there any guidelines for teachers wanting to use technology? Does the curriculum require the use of technology?

8. How often do teachers and students use technology? How do teachers use technology in their classes? Is it seen as an integral part of their lessons or an "add-on"?

Do teachers document, in any way, their use of technology?

10. Can you give me an example of a technology project that didn't work as well as you had hoped? How would you improve it? How would you make sure it worked out better next time?

Technology Available for Teachers

How many teachers work in this school? _____

How many computers are available for teachers in this school? _____

Where are these computers located?

1. On average, how old are these computers in the school? _____

2. Are there laptop computers available for teachers to use or sign out? Yes
   No

   If yes, how many? _____

Are there other devices available for teacher use? (eg fax, scanner, digital cameras, digital video cameras, microphones, etc.) List these devices.

Technology Available for Students

How many students attend this school? _____

How many computers are available for students use? _____

3. Where are these computers located? _____

4. On average, how old are these computers? _____

5. Are there laptop computers available for students to use or sign out? Yes
   No

   If yes, how many? _____

6. Are there other devices available for student use? (eg fax, scanner, digital cameras, digital video cameras, microphones, etc.). List these devices.

Appendix G Teacher Survey Package

a) Technology Implementation Questionnaire (TIQ)

INSTRUCTIONS

This questionnaire has five sections and consists of four printed pages. Please mark ALL your answers on the accompanying Answer Sheet. Circle the most appropriate response when answering the closed-ended questions. Space is provided to record your comments to the open-ended questions. After you have completed your responses, please return both the questionnaire and the answer sheet to your facilitator.

SECTION I- Your Professional Views on Computer Technology

Using the scale provided, please rate the extent to which you agree or disagree with the following statements regarding the use of computer technology in the classroom:

Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
A	B	C	D	E	F

The use of computer technology in the classroom...

1. Increases academic achievement (e.g. grades).
2. Results in students neglecting important traditional learning resources (e.g., library books).
3. Is effective because I believe I can implement it successfully.
4. Promotes student collaboration.
5. Makes classroom management more difficult.
6. Promotes the development of communication skills (e.g., writing and presentation skills).
7. Is a valuable instructional tool.
8. Is too costly in terms of resources, time and effort.
9. Is successful only if teachers have access to a computer at home.
10. Makes teachers feel more competent as educators.
11. Is successful only if there is adequate teacher training in the uses of technology for learning.
12. Gives teachers the opportunity to be learning facilitators instead of information providers.
13. Is successful only if computers are regularly maintained by technical staff.
14. Demands that too much time be spent on technical problems.
15. Is successful only if there is the support of parents.
16. Is an effective tool for students of all abilities.
17. Is unnecessary because students will learn computer skills on their own, outside of school.
18. Enhances my professional development.
19. Eases the pressure on me as a teacher.
20. Is effective if teachers participate in the selection of computer technologies to be integrated.
21. Helps accommodate students' personal learning styles.
22. Motivates students to get more involved in learning activities.
23. Could reduce the number of teachers employed in the future.
24. Limits my choices of instructional materials.
25. Requires software-skills training that is too time consuming.
26. Promotes the development of students' interpersonal skills (e.g., ability to relate or work with others).
27. Will increase the amount of stress and anxiety students experience.
28. Is effective only when extensive computer resources are available.
29. Is difficult because some students know more about computers than many teachers do.
30. Is only successful if computer technology is part of the students' home environment.
31. Requires extra time to plan learning activities.
32. Improves student learning of critical concepts and ideas.
33. Becomes more important to me if the student does not have access to a computer at home.

SECTION II - Your Background, Your Teaching Style and Resources Available to You

34. Gender: A. Female B. Male

35. Years of teaching completed (If this is your first year, indicate '0'on the answer sheet. If last year was your first, indicate '1', and so on.)

36. Current teaching position (If you teach in more than one subject area, choose the one that dominates your teaching schedule.)

Elementary:
A. Pre-K or Kindergarten
B. Cycle 1, grades 1 and 2
C. Cycle 2, grades 3 and 4
D. Cycle 3, grades 5 and 6
E. Other (e.g., Music, Phys. Ed., Science, Resource)

Secondary:
F. Mathematics, Science, or Computer technology
G. Language arts, Second language, MRE, Social Science
H. Special Education or Resource
I. Other (e.g., Creative arts, Phys. Ed., Vocational)

37. Preferred teaching methodology (choose only one)

A. Largely teacher-directed (e.g., teacher-led discussion, lecture)
B. More teacher-directed than student-centered
C. Even balance between teacher-directed and student-centered activities
D. More student-centered than teacher-directed
E. Largely student-centered (e.g., cooperative learning, discovery learning)

38. Average class size that you teach (please provide a whole number and not a range)

For questions 39 and 40, use the following scale to rate your responses

Extremely Poor	Poor	Acceptable	Good	Very Good	Excellent
A	B	C	D	E	F

39. How would you rate student access to computer technology at your school?

40. How would you rate teacher access to computer resource personnel in your school?

SECTION III –Your Experience with Computer Technologies

41. Please indicate how often you integrate computer technologies in your teaching activities.

A. Not at all
B. Rarely
C. Occasionally
D. Frequently
E. Almost Always
F. All the Time

42. On average, how many hours per week do you spend using a computer for personal use outside of teaching activities?

A. None
B. Less than 1 hr
C. 1 hour or more, but less than 3 hours
D. 3 hours or more, but less than 5 hours
E. 5 hours or more, but less than 10 hours
F. 10 hours or more

43. Please read the following descriptions of the proficiency levels a user has in relation to computer technologies. Determine the level that best describes you and circle the corresponding letter on your answer sheet.

A. Unfamiliar
I have no experience with computer technologies.

B. Newcomer
I have attempted to use computer technologies, but I still require help on a regular basis.

C. Beginner
I am able to perform basic functions in a limited number of computer applications.

D. Average
I demonstrate a general competency in a number of computer applications.

E. Advanced
I have acquired the ability to competently use a broad spectrum of computer technologies

F. Expert
I am extremely proficient in using a wide variety of computer technologies.

SECTION IV - Your Process of Integration

For Items 44 to 53:
Please indicate how frequently computer technologies are integrated into your teaching activities for each of the uses listed below. Circle the appropriate response on your answer sheet.

Never	Practically Never	Once in a While	Fairly Often	Very Often	Almost Always
A	B	C	D	E	F

44. Instructional (e.g., drill, practice, tutorials, remediation)
45. Communicative (e.g., e-mail, ICQ, computer conferencing, LCD projector)
46. Organizational (e.g., data base, spreadsheets, record keeping, lesson plans)
47. Analytical/Programming (e.g., statistics, charting, graphing, drafting, robotics)
48. Recreational (e.g., games)
49. Expansive (e.g., simulations, experiments, exploratory environments, brainstorming)
50. Creative (e.g., desktop publishing, digital video, digital camera, scanners, graphics)
51. Expressive (e.g., word processing, on-line journal)
52. Evaluative (e.g., assignments, portfolio, testing)
53. Informative (e.g., Internet, CD-ROM)

54. Total amount of in-service training you have received to date on using computer technology in the classroom:

    A. None
    B. A full day or less
    C. More than a full day and less than a one-semester course
    D. A one-semester course
    E. More than a one-semester course

55. Please read the descriptions of each of the six stages related to the process of integrating computer technology in teaching activities. Choose the stage that best describes where you are in the process and circle the corresponding letter on your answer sheet.

    A. **Awareness**
    I am aware that technology exists, but have not used it – perhaps I'm even avoiding it. I am anxious about the prospect of using computers.
    B. **Learning**
    I am currently trying to learn the basics. I am sometimes frustrated using computers and I lack confidence when using them.
    C. **Understanding**
    I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.
    D. **Familiarity**
    I am gaining a sense of self -confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.
    E. **Adaptation**
    I think about the computer as an instructional tool to help me and I am no longer concerned about it as technology. I can use many different computer applications.
    F. **Creative Application**
    I can apply what I know about technology in the classroom. I am able to use it as an instructional aid and have integrated computers into the curriculum.

SECTION V– Additional Comments

A. Suppose your school administration annually made additional resources available (example: release time) for improving computer-based instruction. In your opinion, what kinds of resources should they provide? How would you like to see these resources used in order to improve your instructional use of computers?

B. Please describe the ideal use, if any, of computer technology in the classroom.

Thank you very much for your participation in our study.

b) Teacher Technology Activities Questionnaire

Teacher Technology Activities

Instructions: The purpose of this questionnaire is to gather examples of technology activities teachers are using in their classes. You may describe the activity, the software you use, how much time you spend on the activity, how many computers are required, and any other detail you feel is relevant.

It is important that you mention if you feel this activity has improved your students' understanding of a topic or their motivation.

For each question you may list more than one activity. Feel free to write on the back of this page.

1. Please list the technology activities you do regularly with your classes.

2. What have been some of your most successful or favourite technology activities?

3. What have been some of your less effective technology activities?

4. List some technology activities that you would like to do with your classes, but you feel that you do not have the skills or knowledge to facilitate this activity?

Appendix H National Education Technology Standards for Students

Technology Foundation Standards for Students

1. Basic operations and concepts
   - Students demonstrate a sound understanding of the nature and operation of technology systems.
   - Students are proficient in the use of technology.

2. Social, ethical, and human issues
   - Students understand the ethical, cultural, and societal issues related to technology.
   - Students practice responsible use of technology systems, information, and software.
   - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

3. Technology productivity tools
   - Students use technology tools to enhance learning, increase productivity, and promote creativity.
   - Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

4. Technology communications tools
   - Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
   - Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5. Technology research tools
   - Students use technology to locate, evaluate, and collect information from a variety of sources.
   - Students use technology tools to process data and report results.
   - Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

Appendix I National Education Technology Standards for Teachers

Technology Foundation Standards for Teachers

I. **Technology Operations and Concepts**
Teachers demonstrate a sound understanding of technology operations and concepts. Teachers:

a. demonstrate introductory knowledge, skills, and understanding of concepts related to technology (as described in the ISTE National Education Technology Standards for Students)

b. demonstrate continual growth in technology knowledge and skills to stay abreast of current and emerging technologies.

B. **Planning and Designing Learning Environment and Experiences.**
Teachers plan and design effective learning environments and experiences supported by technology. Teachers:

a. technology-enhanced instructional strategies to support the diverse needs of learners.
b. apply current research on teaching and learning with technology when planning learning environments and experiences.
c. identify and locate technology resources and evaluate them for accuracy and suitability.
d. plan for the management of technology resources within the context of learning activities.
e. plan strategies to manage student learning in a technology-enhanced environment.design developmentally appropriate learning opportunities that apply

C. **Teaching, Learning, and the Curriculum**
Teachers implement curriculum plans, that include methods and strategies for applying technology to maximize student learning. Teachers:

a. facilitate technology-enhanced experiences that address content standards and student technology standards.
b. use technology to support learner-centered strategies that address the diverse needs of students.
c. apply technology to develop students' higher order skills and creativity.
d. manage student learning activities in a technology-enhanced environment.

D. **Assessment and Evaluation**
Teachers apply technology to facilitate a variety of effective assessment and evaluation strategies. Teachers:

a. apply technology in assessing student learning of subject matter using a variety of assessment techniques.
b. use technology resources to collect and analyze data, interpret results, and communicate findings to improve instructional practice and maximize student learning.

c. apply multiple methods of evaluation to determine students' appropriate use of technology resources for learning, communication, and productivity.

E. **Productivity and Professional Practice**
Teachers use technology to enhance their productivity and professional practice. Teachers:

a. use technology resources to engage in ongoing professional development and lifelong learning.
b. continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology in support of student learning.
c. apply technology to increase productivity.
d. use technology to communicate and collaborate with peers, parents, and the larger community in order to nurture student learning.

F. **Social, Ethical, Legal, and Human Issues**
Teachers understand the social ,ethical ,legal ,and human issues surrounding the use of technology in PK-12 schools and apply those principles in practice. Teachers:

A. model and teach legal and ethical practice related to technology use.
B. apply technology resources to enable and empower learners with diverse backgrounds, characteristics, and abilities.
C. identify and use technology resources that affirm diversity
D. promote safe and healthy use of technology resources.
E. facilitate equitable access to technology resources for all students.