Teachers' Perceptions: barriers and supports to using technology in the classroom

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ABSTRACT   *Fifty-four elementary and secondary school teachers participated in focus-group discussions and completed a survey to examine barriers and supports to computer integration. Although teachers used computers at home and school, they were not wholly comfortable with the technology. Familiarity with computers predicted greater comfort with technology and greater comfort was related to greater integration in the classroom. Thematic analysis of the focus groups yielded six major themes, including issues related to: support, teachers, context and access, students, computer hardware and software problems, and external or other priorities. The discussion of computer integration also inspired substantial emotional responses on the part of teachers. Together, the survey and focus-group findings yielded a framework for identifying individual and environmental issues which impact on computer integration.*

National and international statistics show that schools around the world are becoming increasingly well equipped with computer hardware (Collis *et al*., 1996; Statistics Canada, 1999) and access to the Internet (Statistics Canada, 1999; Greene, 2000; Riel & Becker, 2000). Descriptive statistics reporting Internet connections and pupil/computer ratios, however, tell us little about the quality and quantity of student and teacher interaction with computers. For example, Rosen and Weil (1995) discovered that although computers were available in nearly every school in their study, only one-half of the teachers used the computers. Similarly, Cuban *et al*. (2001) found that only 4 of 13 teachers had modified their classroom teaching in major ways in schools

designated as having high access to computer technology. Likewise, internationally, research studies paint a similar picture, including work conducted in the United Kingdom, Thailand, Greece and the Netherlands (Wooley, 1998; Pelgrum, 2001; Conlon & Simpson, 2003; Demetriadis *et al.*, 2003; Wilson *et al.*, 2003). Since teachers play a pivotal role in determining just how much advantage can be drawn from technology in the classroom (Mercer & Fischer, 1992; Schofield, 1997; Brosnan, 1998), it is clear that we need more than descriptive summaries to understand how computer technology is being integrated. The present study examines the barriers and supports to computer integration from the perspective of the teacher whose role it is to implement the technology in the classroom.

Our knowledge of what affects classroom use of computers is growing rapidly. Most of what is known about barriers and supports follows from surveys (e.g. Rosen & Weil, 1995; Becker & Ravitz, 2001; Specht *et al.*, 2002), or is derived from empirical studies typically addressing one or two specific concerns, such as computer anxiety (e.g. Wood *et al.*, 2002) and, occasionally, observational work (e.g. Sandholtz *et al.*, 1997; Cuban *et al.*, 2001). Together these studies suggest a number of potential variables that can affect the effective integration of technology in the classroom. One thing that these studies do not provide, however, is a context-rich consideration of how these variables are perceived by teachers and how teachers believe that these variables impact on practice.

In order to provide a rich context for understanding the barriers and supports that teachers face, it is critical that teachers be allowed to elaborate and identify their experiences, expectations and shortcomings as they use or consider using technology in their classrooms. Recent investigations, in high-access schools and across school districts (Schofield, 1995; Becker & Ravitz, 2001; Cuban *et al.*, 2001; Windschitl & Sahl, 2002; Conlon & Simpson, 2003) point to the teacher as the key to implementation of computer technology beyond the organizational and environmental barriers. Teachers' knowledge, skill and philosophy are determinants of their instructional methods (Staub & Stern, 2002). Teachers' beliefs, attitudes and emotions also build the meanings they bring to innovations, such as technology integration (van den Berg, 2002), and these same beliefs impact the cognitions and beliefs of the students they teach (Ross *et al.*, 2001). It is important, therefore, that researchers supply knowledge of 'best practice' and innovation using computer technology, but these findings need to be generated and refined with significant input from practitioners (Gersten & Baker, 2000). The present study provides a qualitative examination of elementary and secondary Teachers' perceptions in order to derive a rich understanding of supports and barriers to the integration of technology in their classrooms.

To date, researchers suggest that there may well be many potential barriers to the successful implementation of computer technology. These barriers range from equipment-based issues, such as limited access (Sutton, 1991; Rocheleau, 1995), technical problems and malfunctions (e.g. Hadley & Sheingold, 1993; Sandholtz *et al.*, 1997) to individual differences in attitudes and skills among teachers (e.g. Becker, 1994; Anderson, 1996; Becker & Ravitz, 2001; van den Berg, 2002; Wood *et al.*, 2002) and social issues that impact traditional classroom organization and

social interactions in the classroom (e.g. Podmore, 1991; Schofield, 1995). The rapid advances in computer technology, and the changes within schools regarding the presence of technology, make it challenging to evaluate the impact of these potential barriers over time. For example, given the high prevalence of technology in schools today, the access issues that were highlighted in the early 1990s may no longer be relevant for today's teachers. Short-term longitudinal studies have found significant changes in computer use and technical issues over periods as brief as two years (Conlon & Simpson, 2003).

Similarly, individual characteristics, such as 'technophobia' or computer anxiety, which have been identified as a reason for why teachers do not implement computers despite increased availability of hardware (Rosen & Weil, 1995), may be less of a concern as more teachers with computer experience enter the teaching profession, and as less experienced computer users have greater access to workshops and training. Given that high computer anxiety is typically associated with low levels of knowledge and experience with computers (e.g. Anderson, 1996; Wood *et al*., 2002) and that even simple interventions such as providing teachers with information and practice using computer technology reduce computer anxiety (Wood *et al*., 2002), the degree and prevalence of anxiety may or may not be an issue to teachers.

Apart from potential changes in the impact of barriers derived in the past research, there is also the concern that even if these barriers still exist, they may not represent the issues perceived as most critical by teachers. When teachers respond to closed survey items, rather than open-ended questions, only the issues questioned can be evaluated. There may be other more pertinent issues that have not been identified. In addition, some previous barriers may still be important, but the nature of these barriers may have changed. Such questions can only be assessed through direct and extensive communication with the 'practitioners' in education. Their direct input provides an opportunity to identify potential barriers and to understand the relative importance of barriers when it comes to integrating technology in the classroom

Clearly, changes are occurring with respect to the integration of technology in the classroom (Windschitl & Sahl, 2002). In many cases, there is a reported shift in the teacher's role with teachers assuming the role of facilitator (e.g. Schofield, 1997), interacting with students more and conducting fewer whole-group lessons. Long-term changes, however, are slow (e.g. Sandholtz *et al*., 1997) and mechanisms that support these changes, like the barriers that inhibit them, are not wholly understood. Previously identified supports, such as in-house specialists, technical support, administrative support and opportunities for training (e.g. Sandholtz *et al*., 1997), have face value validity. However, the relative importance of these supports, and others, can only be understood by asking teachers directly.

The present study provides a picture of teachers' perceptions of computer implementation in their classrooms: describing what computers are used for, where they are used, what integration of technology means to individual teachers at the elementary and secondary level, what supports their use of technology and what, if anything, still stands in the way of successful implementation.

Method

Participants

A total of 54 teachers (37 elementary and 17 secondary) from a mid-sized Canadian city participated in one of thirteen 60-minute focus groups. There were 32 female and 5 male elementary teachers and 8 male and 9 female secondary teachers. Ages ranged from 25 to 61 years of age ($M = 40.5$, $SD = 9.17$ years). The majority of the participants had been teaching for several years ($M = 13.32$, $SD = 8.37$ years).

Sampling Procedure

A random sample of 144 potential participants was drawn from a list of all teachers employed by one school board in the previous year (74 elementary school teachers and 70 secondary school teachers). Of the 144 participants, some were no longer available to participate due to illness, death, retirement and maternity leave. Among teachers who were still teaching, there was a response rate of 61% at the elementary school level and 31% at the secondary school level. The lower response rate with the secondary school teachers was related to difficulties in contacting potential participants.

Materials and Procedure

Participants attended one session. At the beginning of each session, participants independently completed a short survey to assess demographic information (including age, gender, total years teaching and highest level of education) and computer use. The computer use section was composed of 16 forced-choice (yes/no) questions regarding computer access and use, both at school and at home. These questions were followed by three short-answer questions regarding amount of time spent on a computer and professional development experiences. Two questions assessed comfort level with computers using a five-point Likert-type scale, where 1 represented 'very at ease/very enthusiastic' and 5 represented 'very ill at ease/not at all enthusiastic.' The last question asked participants about their awareness of a school computer plan and who developed the plan.

Completion of the survey was followed by a focus-group discussion. On average, focus groups contained four members. Each group was composed of teachers from only one instructional level (elementary or secondary). The researcher initiated discussion by inviting participants to share their experiences, ideas and concerns regarding computer technology in education. The discussion was continued by participants. Focus groups were terminated after a 60-minute interval. The focus groups were videotaped and audiotaped and later transcribed.

Results and Discussion

Both quantitative and qualitative techniques were used to analyze the data. Quantitative analyses were conducted on the forced-choice and scaled items from the

survey. Qualitative analyses were used to assess the content of the focus-group discussions.

Quantitative Data Analysis

Computer use and access. The vast majority of teachers indicated that they used a computer at home (91.9% and 94.1%, elementary and secondary levels respectively) for personal (93%) and school-related tasks (94.4%). All of the secondary teachers and 86.5% of elementary teachers indicated that they used a computer at school for school-related tasks.

A $2 \times 2 \times 2$ repeated measures ANOVA was conducted to compare the amount of time spent on a computer at home and at school, as a function of gender and teaching level. There was a significant main effect for location, $F(1,50)$ = 19.00, $p < .001$, such that a greater amount of time was spent at home on the computer than at school ($M = 3.7$ vs. 2.1 hours/week, respectively). No other main effects or interactions were significant.

Within schools, computers were most often located in libraries/resource centers (91.9% and 100%, elementary and secondary respectively) or in labs (83.8% and 94.1%, elementary and secondary, respectively). Among secondary teachers, 58.8% had access to computers in their classroom and 58.8% in a pod work area (detached rooms beside classrooms), whereas only 45.9% of elementary teachers had computers in their classrooms and 24.3% in pods.

The correspondence between the availability of computers and use by students was high for the computers that were available in the classroom or in labs. Computers located in libraries or pods were available but use of these computers was much lower.

Comfort. One 2×2 ANOVA was conducted to assess comfort with computer technology as a function of gender and teaching level. There was a significant main effect for teaching level, $F(1,54) = 7.32$, $p < .009$ such that secondary teachers reported more comfort with computers than elementary teachers.

A multiple regression was conducted to explore possible predictors of comfort with technology. Six variables were entered simultaneously into the analysis: age, gender, number of computer workshops attended, and measures of use (use of computers at home and school), access (having a computer for use at home, school or other place) and support (whether school supports technology for teachers and students). Use of technology emerged as the sole significant predictor, $R^2 = .16$, $F(1,51) = 10.01$, $p < .003$, such that greater computer use was related to higher levels of comfort.

Support and integration of technology. Both elementary and secondary teachers reported having attended, on average, two professional workshops on computer technology ($M = 2.1$, $SD = 2.41$ for elementary, and $M = 2.8$, $SD = 2.33$ for secondary), $t(51) = .93$, $p > .36$. Most teachers indicated that their school supported the integration of technology for students (88.9%) and for teachers themselves (90.7%). However, 75.9% were not aware of a school computer plan at their institution.

A 2 (gender) x 2 (teaching level) ANOVA was conducted to assess the degree to which teachers incorporated the use of computer technology in their lesson planning. Secondary school teachers ($M = 3.8$, 1 representing 'never' to 5 representing 'a great deal') incorporated technology more often than elementary school teachers ($M = 2.7$), $F(1,54) = 8.53$, $p < .01$. The main effect for gender and the interaction between gender and teaching level were not significant.

A multiple regression analysis was conducted to assess which of the following nine variables predict integration of computers in the classroom: age, gender, total years of teaching experience, amount of time spent on computers at home and at school, comfort and access, use and support. Comfort was the only variable accounting for a significant amount of variability in integration, $R^2 = .47$, $F(9,42) = 4.08$, $p = .001$, such that teachers who reported greater comfort with computers were more likely to believe in and support integration of computers in their classroom.

Summary of the Quantitative Data

The majority of participants had experience and familiarity with computers and used them both at home and at school. Use of computers at school appeared to be compromised by location, such that computers located in classrooms and labs were used, whereas computers located in other environments, although available, were not used to their full potential. Consistent with previous research (e.g. Anderson, 1996; Wood *et al*., 2002; Conlon & Simpson, 2003), teachers' use of computers was predicted by higher comfort, and comfort with computer technology was related to the integration of technology within lesson plans. Overall, there were few differences between elementary and secondary teachers, except that secondary school teachers experienced greater ease and enthusiasm about computer technology. It is important to note, however, that both groups identified contexts where computer technology would add to their instruction.

Qualitative Data Analysis: focus groups

The focus-group dialogue was descriptive and uninhibited, with all participants taking an active part in the discussions. The audiotapes for each focus group were transcribed verbatim. The videotapes were used to clarify any unclear portions. Thematic analysis (Boyatzis, 1998) of the transcripts resulted in a two-layered coding system which captured both the content of the discussion and the affect or emotion the teachers attached to that content.

The development of the coding scheme was initiated by independent, open coding of two secondary school transcripts by two principal researchers. Participants' language was used as much as possible to produce a 'data-driven' coding scheme (Guba & Lincoln, 1989). The resulting themes were compared and additions or discrepancies were resolved through discussion between the two coders (Boyatzis, 1998). This preliminary set of themes was used to code an additional transcript. Any novel themes were added to the preliminary coding scheme. To protect against 'projection' and to ensure reliability of the coding scheme, an explicit code of theme

labels, definitions and examples was developed (Boyatzis, 1998). The remaining transcripts were coded using the explicit theme labels and definitions.

At first the transcripts were coded primarily for content themes, but it became apparent that a large portion of the discussion was laden with emotion or affect and this affect was not captured effectively by the content coding. It was important to identify 'how' teachers felt about the topics discussed, i.e. the meanings and attitudes attached to the issues. At this point, the transcripts were reread, 'blocked' into sections of related discussion and each block was coded according to emotion as well as content.

The affective themes included positive, negative, neutral and complex categories. Some of the discussion was incredibly 'positive' and some completely 'negative.' Much of the discussion was 'neutral', stated with little or no obvious affect. This coding scheme allowed us to differentiate between teachers, for example, who stated in a rather neutral tone that there were insufficient numbers of computers, and teachers who expressed utter frustration with the chaos of an inadequate computer lab. The 'complex' coding category identified statements that had both positive and negative emotional responses together (definitions of coding categories are included below). Two raters independently coded four transcripts using this two-layered coding scheme (content and affect) with 89% agreement. All transcripts were then coded by one of the two raters for both the content and affect themes.

Content Themes

Six major content themes were identified: support issues, teacher level issues, context and access issues, student level issues, computer hardware and software problems, and external issues or other priorities. Within each major theme, sub-themes were also identified. For both elementary and secondary teachers, support and teacher-related issues occupied the majority of the discussions (37% and 31% for elementary teachers and 35% and 30% for secondary teachers for the two themes). The pattern of emphasis for the sub-themes within these two global themes was also similar across teaching levels. The prevalence of the remaining themes differed among the elementary and secondary teachers (see Table I for a summary of the frequency for the content themes).

Support Issues

The largest portion of the discussion surrounded the presence or absence of support, specifically support in the form of: human resources; material resources; training and professional development; and administration and parental support.

Human resources. Human resources referred to the presence or absence of people or their positions, including technicians, computer contacts or administrators, computer experts and librarians. Also, general references were sometimes made about a need for supervision of students during computer instruction and the need for smaller classes.

TABLE I. Frequency of themes at content level.

Themes and Subcategories	Percentage of Coded Blocks	
	Elementary	Secondary
Support Issues	**37.4**	**35.1**
Material Resources	48.0	69.6
Human Resources	28.5	19.6
Training and Professional Development	18.7	5.8
Administrative and Parental Support	4.7	4.9
Teacher Level Issues	**31.1**	**29.5**
Philosophy/Pedagogy	46.5	56.9
Skills and Characteristics	30.9	21.3
Curriculum	8.8	19.7
Digital Divide	3.8	2.1
Context and Access Issues	**11.5**	**10.2**
Access	55.2	76.9
Context	44.8	23.1
Student Level Issues	**10.1**	**12.9**
Motivation, Skills and Characteristics	65.7	84.1
Digital Divide	24.5	7.3
Sabotage	9.8	8.5
Computer Hardware and Software Problems	**7.9**	**9.7**
Malfunctions and Problems	48.8	53.2
Compatibility	33.8	16.1
Pace of Change and Outdated Equipment	17.5	30.6
External Issues and Other Priorities	**2.0**	**2.7**
Corporate Programs	45.0	23.5
Community Resources/Skills	35.0	0.0
Textbooks	20.0	76.5

> *and the librarian was supporting little mini enrichment groups across the grades and so now, as you say, what's going to happen…The library is closed for half the day. It does, and then you can't go in there without supervision to these computers. (Elementary)*

Material resources. Discussion of material resources referred to the presence or absence of material resources including equipment, Internet resources, software, programs and systems. Teachers also made frequent reference to the allocation and distribution of equipment and financial support.

> *I think our school is pretty computer rich but even with you know 600 kids sharing basically 40 computers around the school, that sounds like a lot, it's more than a lot of schools have, but it is not enough to teach adequately. (Elementary)*

> *Now we have a home page also and I think it's fantastic that they [students] have access to all of those data bases like, **InfoTrac**, and **Discovering**

> **Authors** *and all of these databases that they can do their assignments from.*
> *(Secondary)*

Training and professional development. This category referred to the presence or absence of training programs or opportunities, evaluation of those programs and/or discussion of a need for training as a support for implementation and use of computers.

> *Same thing even with conferences. I mean hundreds of dollars. I'd love to do some of them but they're not paying for me to go. (Elementary)*

> *I think the school board over the years has done a great job at offering courses on software, learning software packages and stuff. I know I've, over the last 5–10 years, I've taken probably 20 or 30 courses on software just to learn it and I mean when new stuff came out, you learn it and you kind of get a starting point that you can then go from to kind of discover on your own. I think the school board's done a good job from that area. (Secondary)*

Administrative and parental support. This category referred to the presence or absence of support for computer implementation in general or specific ways from government, administration or parents. Communication among administration, departments and teachers regarding computers was also a topic of discussion included in this category.

> *Ha, but the major frustration being though that although the curriculum and the government are asking us to do all these wonderful programs and I believe in the validity of that, but they're not keeping up with their end of the bargain and providing us with things that are workable with the classes that you have. (Elementary)*

Overall, human and material resources accounted for the majority of the discussion in this support theme, followed by training and professional development, and finally administrative and parental support. Although a greater percentage of the secondary (69.6%) compared to elementary (48%) discussions involved material resources, this sub-theme was the most prevalent for both groups. Secondary teachers described support through well-equipped labs but they also identified inequities among schools and departments within schools. For example,

> *And that's the difference too, depending on what you are hearing is that some schools are technology rich and others not. I find that amazing. Our school is all Internet linked and you hear other schools that are working with these relics.*

Elementary teachers spoke more about human resources (28.5%) than secondary teachers (19.6%). Their discussions included requests for additional supervision of young students in labs and the loss of librarians who were often the computer 'experts.' Their discussions made it clear that having a teacher within the school who was knowledgeable and enthusiastic about computers was a catalyst for

school-wide integration. In comparison, secondary teachers discussed the loss of technical assistance personnel and site administrators.

Similarly, training and professional development was a larger portion of the support issues category for elementary teachers (18.7%) than for secondary teachers (5.8%). Secondary teachers talked about specific training and didn't see this as a major barrier while elementary teachers noted the need for training in troubleshooting and specific applications of computers in the classroom.

Teacher Level Issues

Approximately one-third of the codings related to teacher issues (31.1% of the elementary and 29.5% of the secondary) with four subcategories: philosophical and pedagogical issues, skills and characteristics of teachers, curriculum and digital divide.

Philosophical and pedagogical issues. This category referred to beliefs about if, when, and how computers fit within teaching and learning. References to the computer as a tool were part of this subcategory. Teaching methods, strategies and examples of computer-related activities were also included.

> *Get bio's, get any specs on the movie that they can get. So it's a really useful tool in terms of accessibility of information for me because of course I teach English so I don't use it in the same way that you would use computers. (Secondary)*

Skills and characteristics. This category included references to the skills, knowledge, comfort and experience level of teachers who do or do not use computers. Statements that referred to the time or interest an individual teacher spends with computers were included here.

> *I mean, I can turn one on, I can send e-mail, I can write an essay on it, I can write letters with my kids, but if you're asking me to fix something, you're barking up the wrong tree. (Elementary)*

Curriculum. This category refers to curriculum guidelines and expectations. Discussions surrounding 'too much stuff to fit into the curriculum' are also included here.

> *And I would say that's a general problem, just as a teacher-librarian and seeing all different subject areas, one of the major complaints is, again we'll talk here about the government and curriculum, is that it is so content-driven…as a result, a lot of things that were extremely worthwhile to do, including giving your classes time to say go work in a lab or go work in the library on an assignment, the teachers aren't doing it anymore. (Secondary)*

Digital divide. Specific references were made to a division in terms of computer experience and/or expertise between teachers or between teacher and student.

> *But an awful lot of the kids at the grade level that I am teaching have way more expertise than the teachers. (Elementary)*

Overall, among these four subcategories, approximately half of the teacher issues discussion included philosophical and pedagogical issues (46.5% elementary and 56.9% secondary). Teachers gave examples of how they used computers in their instruction, for example, word processing, play, computer skill instruction, resource, simulations, presentations and others. There was some debate as to whether and how computers should be integrated with arguments regarding developmentally appropriate tasks for children and loss of traditional, basic skills.

Discussion of skills and characteristics of teachers were more common in the elementary focus groups (30.9%) than the secondary groups (19.7%). The elementary teachers spent more time discussing their own individual experience with technology. Some elementary teachers related a lack of confidence in their own computer knowledge and stated that as a barrier to including it in their planning. The secondary teachers talked about curriculum and how computers did or did not fit within the content they were teaching. For the secondary teachers, the issues seemed to be less about individual characteristics of the teacher and more about what was being taught.

Context and Access Issues

Discussion topics that were coded into this category referred to issues surrounding the location in which computers were placed in the school. There also were issues surrounding the access to the computers in these locations.

Access. Discussions in this category revolved around the ability or lack of ability to book labs, find time in the schedule for computer use and generally gaining 'access' to computers and software.

> *The thing is it's difficult to book in times for your class to use the computer lab because there are so many classes and there will be times in the year when, for example, the grade 3's are all doing that learning how to type thing. (Elementary)*

Context. This category included references to the setup and consequences of where computers are used (i.e. in a lab, classroom, pod, library).

> *Now nobody's facing you, everybody's spinning around and I mean, the classes next year, our classes are going to balloon again, and I mean this year it was great, I had small classes, you were able to do a lot with them. Next year again, and when you want, if you get computers in your classroom, now the students are shut off from the teacher unless you've got such small classes that they can work in one part of your room and then you can move them to doing something else in the other half of your room. But some schools have really teeny rooms, I mean if you were at **** you wouldn't be able to do it because the rooms are so small. (Secondary)*

The access and location theme was the third most prevalent issue raised by elementary teachers and the fourth most prevalent for secondary teachers. For both groups,

access was the more prevalent of the two issues, especially for the secondary teachers (76.9% versus 55.2% for elementary). The secondary teachers frequently mentioned getting access to computers in labs as a necessary component of their instruction and that access was not always available. Elementary school teachers more frequently discussed wanting access to computers in their classrooms. In particular the elementary teachers explained the difficulties of moving a class of young children to a lab for computer instruction and the challenges of integrating technology into the curriculum when it was so far removed from the ongoing activities that were taking place in the classroom.

Student Level Issues

Direct reference to students and computers were also made but to a lesser extent than the support and teacher issues. The quotes regarding students were divided into three subcategories.

Motivation, skills and characteristics. This category included discussion about the knowledge and skills that students have or need, as well as their motivation, opinions and feelings surrounding computer use. Teachers also made comments about differences and difficulties related to the developmental stages and characteristics of students.

> *you'll go around and my students will say, 'I can't find anything', and they're doing a Yahoo search and you say, because you already have 10 links, 'Did you try one of those?' 'Well, no, I just went to Yahoo.' A lot of them, their Internet search skills are really weak. They don't know how to focus. (Secondary)*

Sabotage. Some discussion included problems related to vandalism or 'sabotage' of computers by students. References to 'hackers' or students interrupting the operating system were included here as well.

> *That would become dangerous in my school because I have kids who could hack into it and change it. (Elementary)*

> *we had 2 weeks this year where some student at our school…I think it was board wide, where some student had set up…a dialing, set up a program where the board's computers were being dialed by some phone number at light speed. (Secondary)*

Digital divide. Specific references were made to a distinction among students according to computer access and/or computer skill. Differences also were identified between the computer systems students used at home and those available at school in terms of quality and Internet speed.

> *And that's probably something that needs to be taken into account. Not all kids have computers at home so maybe we should be focusing more on computer use at school rather than rely on the opportunities that they might*

have at home to use it. So to put more time into usage of computers at school. (Elementary)

And they're always complaining about how outmoded our computers are at the school compared to the ones they have at home. (Secondary)

The student theme was the fourth most prevalent theme for elementary teachers and the third for secondary teachers. Within the theme, however, for both levels of teachers, the subcategory of motivation, knowledge and skills of the students captured the majority of discussion. Specifically, teachers at both levels complimented children who were knowledgeable and enthusiastic about computers, and noted that the computer skills of students often surpassed that of the teacher, such that students were often used as peer teachers. For example,

I give the kids the programs. I tell them to learn them and then come back and show me. And that's how I became a computer expert. I used the kids. (Elementary)

The elementary teachers discussed the digital divide (24.5%) more than secondary teachers (7.3%). The concept of digital divide spanned differences in knowledge about computers and/or quality of equipment among students, schools, students and teachers, and the school versus home environment. When schools were disadvantaged, teachers indicated that students were frustrated with the level of technology they had to work with at school compared to what they had in their homes. Overall, there was very limited focus on sabotage by students.

Computer Hardware and Software Problems

A relatively small percentage of the focus-group discussions related to problems with computer hardware, software or systems (7.9% of elementary and 9.7% of secondary). Issues discussed at this level concerned not the presence or absence of resources but problems using those resources in terms of malfunctions, compatibility and change. For example,

[Malfunctions] We have computers in all the shops and other rooms but we have, as you're experiencing, once a week the server goes down and takes out 3 or 4 classrooms at the same time…that is if the power doesn't go down completely! (Secondary)

[Compatibility] Maybe that means that some of the secretaries need to have some additional training too. The first year when I was at ****, the first year I was there I did it all on IBM and something happened on the merge and I had to re-do my entire report card. So, since then I've done it on my Mac at home. But there are people who are still doing it on their IBM's and it is not a problem. (Elementary)

[Pace of Change/Outdated Equipment] And then as soon as you've taken that course, that software is outdated. I've taken several and gotten pretty happy about what I'm doing with this particular software, and the next thing you know that won't load on this computer anymore. (Elementary)

For both groups of teachers, malfunctions were perceived as a huge barrier to planning and integration. Teachers related stories of weeks of planning and entire lessons going to waste because of breakdowns during class or loss of computer files. Although there was extreme frustration regarding this topic when it was discussed, it was not as major a focus of discussion as might be expected. It did appear to be a problem that many teachers were accepting and that was being addressed by new equipment and better systems. The secondary panel had more discussion about outdated equipment and the pace of change and less compatibility talk. They discussed how the perpetual change in the world of technology creates difficulties for teachers who are trying to keep students informed.

External Issues and other Priorities

External issues and other priorities accounted for less than 3% of the discussion for both elementary and secondary teachers. The issues raised included references to the use of computers in the wider community (beyond the school), technical assistance available from corporate programs, and the priority of textbooks beyond computers.

> *[Community] Well at my husband's work everything is done on the computer. If he is signing up for anything to do with human resources, anything to do with a benefit plan, anything to with anything, they do not use paper and it's all on computer and I don't know if our kids could do it. (Elementary)*

> *[Corporate programs] I guess the other thing, I guess we didn't mention is that there is a program called Libraries to Schools or something along that…where you can get free computers, old computers from businesses…they get refurbished and then the school board sends them out if you request them and there's no cost but there's no service once you get them. (Secondary)*

> *[Textbooks] You won't know until the year starts which textbook your teacher chose. You won't know in terms of planning so I'm wondering what kind of impact that may have. Are they going to put some things on line? I feel they have to address this issue because really, the money is not there for the text-books. What's going to happen to these students that can't take home a textbook? Where are they going to get the material from? (Secondary)*

Although discussion of this theme was infrequent, the elementary teachers' discussion was split among the three subcategories. The key points focused on collaboration with private companies who shared old equipment, and government programs designed to use schools as a place to house computers which community members could use. Secondary teachers discussed textbooks. Specifically, they thought that money should not be taken from needed textbook funding to add to computer technology.

Affect or Emotion-based Themes

Discussion of computer integration generated a lot of emotion. Four major themes described 'how' the teachers felt about 'what' they were saying: positive, negative,

TABLE II.   Frequency of themes at affect level.

| Theme | Percentage of Total Number of Coded Blocks | |
	Elementary	Secondary
Complex	38.0	30.1
Complex: Positive	19.2	14.7
Complex: Negative	18.8	15.4
Neutral	31.2	34.0
Negative	21.9	24.0
Positive	9.0	11.9

Note: percentages listed for Complex: Positive and Complex: Negative combine to create the total for Complex theme.

neutral and complex. Overall, the complex and neutral themes accounted for the majority of the discussions, followed by negative affect (see Table II for a summary of prevalence).

Complex affect. Blocks of information that were neither clearly negative nor positive in affect but contained components of both were coded as complex. That is, many times a block contained a positive point that was qualified by a negative comment, or a negative point that was qualified by a positive comment. Generally these were the blocks that included statements followed by 'but', 'if' or 'when.'

> *Just getting all the hardware together, they put in all this fibre optics in the schools, they make this big deal, oh this fibre optics, it'll make everything so wonderful and ours is all done and it's no different than it was before, it's all garbage [negative]. The Internet jams…I'd love to use the computer lab, go in there and do research, do lessons, you know, you could do so much [positive] but you can't until they get this all straightened out. (Elementary)*

The complex theme accounted for the greatest portion of the elementary codings (38%). This was the second most prevalent theme for the secondary teachers, following the neutral theme (see Table III for a complete summary). Support and teaching issues, again, served as the content area where the majority of this affect was being expressed. For the most part, this category related the barriers to successful implementation. For example, elementary teachers appreciated access to labs, but they noted that they couldn't supervise a class of 27 primary children alone in a lab. The supervision difficulties included problems in moving large numbers of small children and monitoring them while they were working on the computers. Both elementary and secondary teachers made positive comments surrounding philosophical and pedagogical issues and they highlighted teachers with strong skills in technology domains but these remarks were qualified with problems in the area of support. That is, they supported the idea of computer integration but felt that the support they needed to execute it effectively was not available. For example,

TABLE III.   Frequency of content themes in complex affect theme: separated by positive and negative.

Content Theme	Positive		Negative	
	Elementary	Secondary	Elementary	Secondary
Support Issues	**43.8**	**42.6**	**38.9**	**38.8**
Material Resources	51.8	80.0	39.2	60.5
Training and Professional Development	23.5	7.5	18.9	13.2
Human Resources	22.4	10.0	32.4	21.1
Administrative and Parental Support	2.4	2.5	9.5	5.3
Teacher Level Issues	**40.2**	**44.7**	**21.6**	**25.5**
Philosophical and Pedagogical Issues	67.9	64.3	22.0	32.0
Skills and Characteristics	23.1	26.2	46.3	32.0
Curriculum	7.7	9.5	26.8	36.0
Digital Divide	1.1	0.0	4.9	0.0
Student Level Issues	**6.7**	**7.4**	**11.1**	**9.2**
Motivation, Skills and Characteristics	100.0	100.0	0.0	0.0
Computer Hardware and Software Problems	**0.0**	**0.0**	**13.7**	**19.4**
Malfunctions and Problems	0.0	0.0	46.2	42.1
Compatibility	0.0	0.0	34.6	31.6
Pace of Change and Outdated Equipment	0.0	0.0	19.2	26.3
Context and Access Issues	**6.1**	**4.3**	**13.7**	**7.1**
Access	58.3	50.0	53.8	57.1
Context	41.7	50.0	46.2	42.9
External Issues and Other Priorities	**3.1**	**1.1**	**1.1**	**0.0**
Corporate Programs	50.0	0.0	100.0	0.0
Community Resources/Skills	33.3	0.0	0.0	0.0
Textbooks	16.7	100.0	0.0	0.0

I think it's wonderful [computer technology] but you know there's so many things that can take away from the use—whether it's maintenance, or new machines, or training teachers. (Secondary)

And that's the kind of story [lost websites] that stops me from spending 3 hours setting something like that up, it's not that I don't have the desire, it's not that I don't see a link to good learning, or I believe 100% in best practice, you couldn't get a best practice tool that's better, but... (Elementary)

Neutral. Blocks that did not demonstrate any obvious negative or positive affect were coded as neutral (see Table IV for a summary).

It's a tool. I mean if you, if you gave them a book and you said find info in the book, they have to know how to use it and read the contents or the index and if you give them a computer, you say find info on the Internet or write something or whatever too. It's a tool… (Secondary)

Overall, approximately one-third of the discussion blocks were coded as neutral (31.2% of elementary and 34.0% of secondary). The elementary panel's

TABLE IV.   Frequency of content themes in neutral affect theme.

Content Theme	Elementary	Secondary
Support Issues	**36.8**	**27.6**
Material Resources	54.3	63.3
Human Resources	29.3	28.3
Training and Professional Development	12.9	0.0
Administrative and Parental Support	3.4	8.3
Teacher Level Issues	**28.6**	**31.3**
Philosophical and Pedagogical Issues	40.0	69.1
Skills and Characteristics	28.9	13.2
Curriculum	21.1	13.2
Digital Divide	6.7	4.4
Context and Access Issues	**13.0**	**13.8**
Access	51.2	86.7
Context	48.8	13.3
Student Level Issues	**10.8**	**16.1**
Motivation, Skills, and Characteristics	47.1	85.7
Digital Divide	47.1	8.6
Sabotage	5.9	5.7
Computer Hardware, Software Problems	**7.9**	**7.8**
Malfunctions and Problems	44.0	35.3
Compatibility	44.0	11.8
Pace of Change and Outdated Equipment	12.0	52.9
External Issues and Other Priorities	**2.9**	**3.2**
Community Resources/Skills	44.4	0.0
Corporate Programs	55.6	28.6
Textbooks	0.0	71.4

neutral discussions involved mostly support and teacher issues with the greatest concentration on support issues (see Table IV). Secondary teachers generated more neutral affect when discussing teacher issues (31.3%) than when discussing support issues (27.6%). The neutral discussion was generally statement of fact, giving a picture of computers in education at the present with reference to material and human resources available and the beliefs of teachers regarding technology.

Negative affect. Negative affect was evident in blocks of the transcripts where teachers degraded or dismissed concepts or technologies with a negative comment. The affect was clearly negative with no redeeming additions or qualifications (see Table V for a summary).

> *But doesn't it kill you that they only usually train one person. That's frustrating. Like, we'll train one person for a staff of 38. (Elementary)*

> *But it's, I mean, as I said, it's been years and years, and you fight and you fight, and it's just so discouraging to have something that I've built up for 10 or 12 years and now next year it's gone. (Secondary)*

Overall, support issues (33% of elementary and 34.6% of secondary) dominated the negative affect codings, followed by teacher issues. Material resources occupied

TABLE V.   Frequency of content themes in negative affect theme.

Content Theme	Elementary	Secondary
Support Issues	**33.0**	**34.6**
Material Resources	43.8	75.5
Human Resources	28.8	15.1
Training and Professional Development	20.5	3.8
Administrative, Board, Parental Support	6.8	5.7
Teacher Level Issues	**28.9**	**19.6**
Skills and Characteristics	35.9	16.7
Curriculum	29.7	60.0
Philosophical and Pedagogical Issues	29.7	23.3
Digital Divide	4.7	0.0
Context and Access Issues	**14.9**	**11.1**
Access	57.6	76.5
Context	42.4	23.5
Computer Hardware, Software Problems	**13.1**	**17.0**
Malfunctions	55.2	73.0
Compatibility	24.1	7.7
Pace of Change and Outdated Equipment	20.7	19.2
Student Level Issues	**8.6**	**13.1**
Motivation, Skills and Characteristics	68.4	75.0
Sabotage	15.8	10.0
Digital Divide	15.8	15.0
External Issues and Other Priorities	**1.4**	**4.6**
Textbooks	66.7	100.0
Community Resources	33.3	0.0

most of the support issues discussed negatively by secondary teachers whereas elementary Teachers' negative comments were more evenly distributed across material and human resources, and training/professional development. The negative comments often relayed frustration with equipment and lack of support. They generally took the form of complaints about inadequacies in terms of materials, people or time. Although the general tone of the discussion groups was supportive of technology, the negative affect depicted barriers that were perceived as insurmountable or related to individuals experiencing enough difficulties to build a disdain for technology. They were 'fed-up' with constant change and afraid to plan computer integration only to be let down again.

Positive affect. Blocks that included any affirmative statements, endorsements or emotional comments indicating positive support for technology, with no qualifications or negative factors, were coded as positive.

   When a new program comes out and you look at the advantages of a new program, you want to immediately start using it. (Elementary)

TABLE VI.   Frequency of content themes in positive affect theme.

Content Theme	Elementary	Secondary
Teacher Issues	**45.1**	**30.3**
Philosophical and Pedagogical Issues	70.7	78.3
Skills and Characteristics	19.5	17.4
Curriculum	9.8	0.0
Digital Divide	0.0	4.3
Support Issues	**34.1**	**43.4**
Material Resources	45.2	69.7
Human Resources	32.3	21.2
Training and Professional Development	22.6	9.1
Student Level Issues	**16.5**	**14.5**
Motivation, Skills, and Characteristics	80.0	100.0
Digital Divide	20.0	0.0
Context and Access Issues	**4.4**	**9.2**
Access	75.0	71.4
Context	25.0	28.6
External Issues and Other Priorities	**0.0**	**2.6**
Corporate Programs	0.0	100.0

> *So I like using the computer for research because it opens up access, you know, to so much more information that you wouldn't have just using library books. (Secondary)*

Opposite to the negative affect outcomes, positive affect was more frequent for teacher issues than support issues in the elementary Teachers' discussion (see Table VI for a summary). In comparison, the secondary teachers focused on support as a positive issue followed by teacher issues, again a reversal from the negative content. Most of the positive comments in the teacher issue theme related to philosophical and pedagogical issues. Teachers generally endorsed computers as an effective instructional tool. With respect to support issues, teachers focused on material resources—making positive comments about the hardware and software available to them. Their positive endorsements were directed at sufficient computer equipment, qualified colleagues and motivated/skilled students.

General Discussion

There were two major findings in the quantitative data. First, consistent with past research (Hadley & Sheingold, 1993; Becker, 1994), use of technology predicted greater comfort with technology. Second, comfort with technology was the only significant predictor of integration of technology in the curriculum. Together, this pattern of outcomes suggests that one of the most critical features for the integration of technology is the individual teacher's level of experience and comfort with technology.

The focus groups, however, indicated that even though the teachers had computer experience they were not wholly comfortable with technology. Why are experienced computer users not comfortable with technology? There are two possibilities. First, this inconsistency may simply be a reflection of progress.

Computer technology may be following the path of any innovation in teaching with the necessary time delay from entry to integration (Armstrong & Casement, 1998). Specifically, technology is increasingly becoming a part of the educational environment and integration is a relatively recent demand. As teachers gain more experience with technology, one would expect that they would become more comfortable with it over time. That 'time' was identified as a persistent barrier by teachers in terms of fitting in curriculum, planning lessons, troubleshooting computer glitches, and teacher training and development. The present results might be reflecting the midpoint in the change.

Alternatively, the inconsistency may be a reflection of the constantly changing face of technology, where teachers may never become experts. In other words, teachers find themselves in the role of a 'perpetual novice.' Technology changes rapidly, particularly with respect to Internet and web-based applications. Prior experience and success with this innovation are necessary for teachers to develop a sense of self-efficacy and a feeling of mastery before they are comfortable integrating this technology within their teaching (Eastin & La Rose, 2000). Teachers face challenges in keeping current, let alone ahead, in their planning. The rapidity of change and the flexibility needed to plan around such a dynamic system increase workload, vigilance and frustration to a level not experienced in other lesson preparations.

Given the persistent novelty and innovation in the field of computer technology, it is not a surprise that teachers focus on their competencies and skill development in this area rather than on how it impacts on the learner. In fact, Borich (2000) suggests that teachers move through three stages of concern. First, they focus on themselves and how they, as individual teachers, will survive. Second, they move to concerns related to the task (e.g. teaching methods and materials), until finally they develop a concern for the impact of teaching on the learner. The majority of teachers in our sample can be characterized as being in the initial stage of development with respect to technology. In order to see a shift from the self to the learner, these teachers see a need for more practice and experience.

It is clear that the level of external support offered to teachers plays a critical role in their comfort with computers (e.g. see Becker, 1994; Sandholtz *et al.*, 1997). In fact, external support might be a necessary prerequisite to having all teachers integrate technology in the curriculum. Indeed, within the broader area of information and communications technologies, there is widespread recognition of the need for ongoing professional support to integrate technologies effectively (Pelgrum, 2001; Van Melle *et al.*, 2003). Similarly, the focal point for the majority of discussions in the focus groups in the present study centred on the need for personnel and material resources to support their integration of technology.

It is important that we keep in perspective the demands that we place on teachers. Teachers have many demands on their time and their skills, from curriculum issues to student management and accountability. Not only is the integration of technology a new innovation but its integration may demand changes in the role of the teacher (Hadley & Sheingold, 1993; Becker, 1994; Schofield, 1995; Riel & Becker, 2000), specifically from traditional models to ones that are more interactive, facilitator based and organized around smaller groups or individuals. Expecting teachers

to be fluent in all aspects of technology, ranging from hardware to software issues, asking them to integrate computers into the curriculum, as well as requiring them to adapt their teaching style, may be too much to ask without a great deal of support.

Van den Berg (2002) suggests that teachers' reactions to externally imposed expectations (in this case, computer integration) and changing internal conditions (role of teacher and possibly changes in pedagogy) are often 'ambiguous, filled with emotion, and even contradictory' (p. 580). Affect or emotion was an important component of the focus-group discussions in the present study and a definite part of the message teachers wished to impart. The complex component of the affect category in the coding scheme here indicates that the integration of computer technology is not as straightforward as supplying materials and support but also is accompanied by beliefs, attitudes and attached meanings. These more subjective components must also be recognized and considered in any form of program development or support.

In fact, approximately two-thirds of the discussion contained an identifiable affective component. Although the affect was mixed, the discussion was more often negative than positive. Despite the frustration that was evident, the positive affect that was present offers a picture that includes some supports and possibilities for successful implementation of computer technology. To get an accurate picture of teachers' perception toward integrating technology, it is important to look at both the affect that teachers experienced and the content that they referred to when they were experiencing these emotions.

Although many of the barriers identified by these teachers (knowledge, time, comfort level, support and technical issues) were also identified in past research (e.g. see Anderson, 1996; Schofield, 1995; Cuban *et al*., 2001; Pelgrum, 2001; Conlon *et al*., 2003), some barriers were less prevalent (limited number of computers, technical difficulties and computer anxiety), suggesting that the focus of computer integration has shifted from hardware/software/technical concerns to individual and wider environmental influences.

Overall, analysis of the focus-group discussions presents a complex, multifaceted framework for examining the successful implementation of technology within the school system. Fig. 1 identifies the barriers and supports that limit and facilitate the integration of computer technology at two levels: the individual teacher and the environment in which the teacher works. The variables external to the teacher include such things as where computers are located, how much support is available or needed, curriculum demands and the match of the available technology to meet these demands, student characteristics and whether the instructor is working with younger or older children. The variables specific to the individual teacher include the teachers' level of familiarity and comfort with technology, their training, their own beliefs and practices about what constitutes appropriate instruction, and how they feel about technology and change.

In summary, the framework depicts the global issues that teachers perceive to be important and hence sets the groundwork for further investigation of factors that predict integration of technology in different environments and across different groups of individuals. In this framework, the teacher is key to our understanding of what is currently happening within schools. It is teachers that have the primary
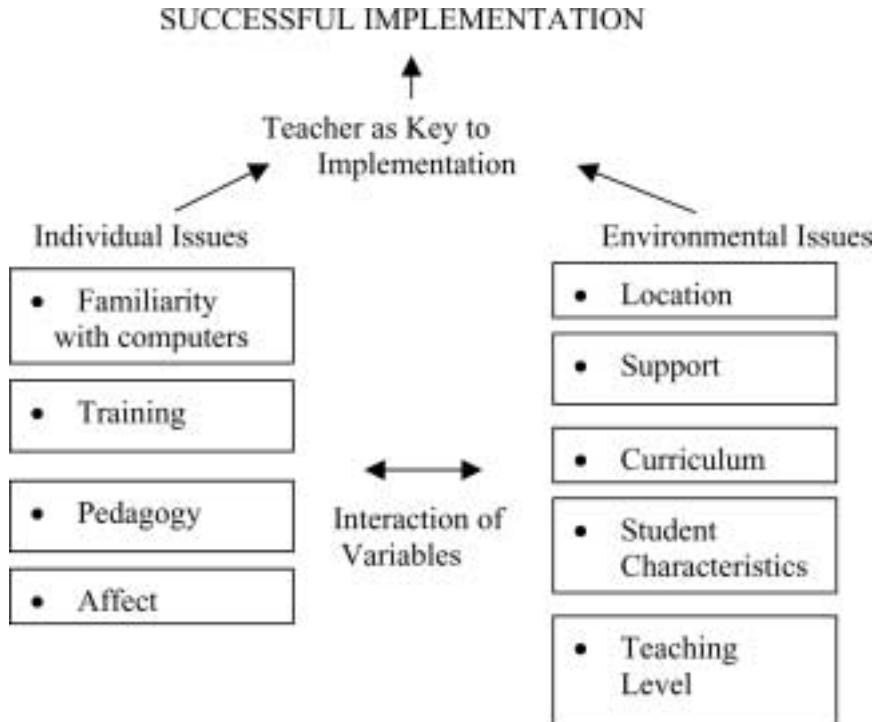
SUCCESSFUL IMPLEMENTATION

FIG. 1.   Framework for examining the implementation of computer technology.

contact with students and teachers that experience the barriers and supports to the integration of technology first hand and change will not occur without teacher consultation and their ownership of the process (Browne, 2002). What is needed now, however, is to consider how the individual and environmental variables inter-act and what interventions can mediate the barriers to computer integration. Under-standing the perceptions of teachers provides a means for addressing the barriers and increasing supports in a way that will be meaningful in the classroom setting. Providing meaningful interventions will enhance the possibility of successful inte-gration of technology for the teachers and the students that they teach.

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REFERENCES

ANDERSON, A.A. (1996) Predictors of computer anxiety and performance in information systems, *Computers in Human Behavior,* 12, pp. 61–77.

ARMSTRONG, A. & CASEMENT, C. (1998) *The Child and the Machine* (Toronto, Key Porter Books).

BECKER, H.J. (1994) How exemplary computer-using teachers differ from other teachers: implications for realizing the potential of computers in schools, *Journal of Research on Computing in Education,* 31, pp. 356–385.

BECKER, H.J. & RAVITZ, J.L. (2001) Computer use by teachers: are Cuban's predictions correct?, paper presented at the *Annual Meeting of the American Educational Research Association,* Seattle, WA, March.

BORICH, G.D. (2000) *Effective Teaching Methods* (Upper Saddle River, NJ, Prentice Hall).

BOYATZIS, R.E. (1998) *Transforming Qualitative Information. Thematic Analysis and Code Development* (Thousand Oaks, CA, Sage Publications).

BROSNAN, M.J. (1998) The impact of psychological gender, gender-related perceptions, significant others, and the introducer of technology upon computer anxiety in students, *Journal of Educational Computing Research,* 18, pp. 63–78.

BROWNE, E. (2002) Information and communications technology and the management of change in two post-compulsory educational institutions, *Research in Post-compulsory Education,* 7, pp. 177–188.

COLLIS, B.A., KNEZEK, G.A., LAI, K., MIYASHITA, K.T., PELGRUM, W.J., PLOMP, T. & SAKAMOTO, T. (1996) *Children and Computers in School* (Mahwah, NJ, Lawrence Erlbaum Associates).

CONLON, T. & SIMPSON, M. (2003) Silicon Valley versus Silicon Glen: the impact of computers upon teaching and learning: a comparative study, *British Journal of Educational Technology,* 34, pp. 137–150.

CUBAN, L., KIRKPATRICK, H. & PECK, C. (2001) High access and low use of technologies in high school classrooms: explaining an apparent paradox, *American Educational Research Journal,* 38, pp. 813–834.

DEMETRIADIS, S., BARBAS, A. MOLOHIDES, A., PALAIGEORGIOU, G., PSILLOS, D., VLAHAVAS, I., TSOUKALAS, I. & POMBORTSIS, A. (2003) 'Cultures in negotiation': Teachers' acceptance/resistance attitudes considering the infusion of technology into schools, *Computers and Education,* 41, pp. 19–37.

EASTIN, M. & LA ROSE, R. (2000) Internet self-efficacy and the psychology of the digital divide, *Journal of Computer Mediated Communication,* 6, pp. 1–24.

GERSTEN, R. & BAKER, S. (2000) What we know about effective instructional practices for English language learners, *Exceptional Children,* 66, pp. 454–470.

GREENE, B. (2000) Teachers' tools for the 21st century: a report on teachers' use of technology. US Department of Education, Office of Educational Research and Development.

GUBA, E & LINCOLN, Y. S. (1989) *Fourth Generation Evaluation* (Thousand Oaks, CA, Sage).

HADLEY, M. & SHEINGOLD, K. (1993) How exemplary computer-using teachers differ from other teachers: implications for realizing the potential of computers in school, *Journal of Research on Computing in Education,* 26, pp. 291–321.

MERCER, N. & FISHER, E. (1992) How do teachers help children learn? An analysis of teachers' interventions in computer-based activities, *Learning and Instruction,* 2, pp. 339–355.

PELGRUM, W.J. (2001) Obstacles to the integration of ICT in education: results from a worldwide educational assessment, *Computers & Education,* 37, pp. 163–178.

PODMORE, V.N. (1991) 4-year-olds, 6-year-olds, and microcomputers: a study of perceptions and social behaviours, *Journal of Applied Developmental Psychology,* 12, pp. 87–101.

RIEL, M. & BECKER, H. (2000) The beliefs, practices, and computer use of teachers, paper presented at the *American Educational Research Association,* New Orleans, LA, April.

ROCHELEAU, B. (1995) Computer use by school-age children. Trends, patterns, and predictors, *Journal of Educational Computing Research,* 12, pp. 1–17.

ROSEN, L.D. & WEIL, M.M. (1995) Computer availability, computer experience and technophobia among public school teachers, *Computers in Human Behavior,* 11, pp. 9–31.

ROSS, J. A., HOGABOAM- GRAY, A. & HANNAY, L. (2001) Effects of teacher efficacy on computer skills and computer cognition in Canadian students in Grades K-3, *Elementary School Journal,* 102, pp. 141–156.

SANDHOLTZ, J.H., RINGSTAFF, C. & DWYER, D.C. (1997) *Teaching with Technology. Creating Student-centred Classrooms* (New York, Teachers College Press).

SCHOFIELD, J.W. (1995) *Computers and Classroom Culture* (Cambridge, Cambridge University Press).

SCHOFIELD, J.W. (1997) Computers and classroom social processes—a review of the literature, *Social Science Computer Review,* 15, pp. 27–39.

SPECHT, J., WOOD, E. & WILLOUGHBY, T. (2002) What early childhood educators want to know about computers, *Canadian Journal of Learning and Technology,* 28, pp. 31–40.

STATISTICS CANADA (1999) Characteristics and features of education systems, in: *Education Indicators in Canada. Report of the Pan-Canadian Education Indicators Program,* Chapter 3, pp. 25–74 (Ottawa, Statistics Canada).

STAUB, F.C. & STERN, E. (2002) The nature of teachers' pedagogical content beliefs matter for students' achievement gains: quasi-experimental evidence from elementary mathematics, *Journal of Educational Psychology,* 94, pp. 344–355.

SUTTON, R.E. (1991) Equity and computers in the schools: a decade of research, *Review of Educational Research,* 61, pp. 475–503.

VAN DEN BERG, R. (2002) Teachers' meanings regarding educational practice. Review of *Educational Research,* 72, pp. 577–625.

VAN MELLE, E., CIMELLARO, L. & SHULHA, L. (2003) A dynamic framework to guide the implementation and evaluation of educational technologies, *Education and Information Technologies,* 8, pp. 267–285.

WILSON, J., NOTAR, C. & YUNKER, B. (2003) Elementary in-service teachers' use of computers in the elementary classroom, *Journal of Instructional Psychology,* 30, pp. 256–263.

WINDSCHITL, M. & SAHL, K. (2002) Tracing teachers' use of technology in a laptop computer school: the interplay of teacher beliefs, social dynamics, and institutional culture, *American Educational Research Journal,* 39, pp. 165–205.

WOOD, E., WILLOUGHBY, T., SPECHT, J., STERN-CAVALCANTE, W. & CHILD, C. (2002) Developing a computer workshop to facilitate computer skills and minimize anxiety for early childhood teachers, *Journal of Educational Psychology,* 94, pp. 164–170.

WOOLEY, G. (1998) Connecting technology and learning, *Educational Leadership,* 55, pp. 62–65.