Report on the Evaluation of the Mathematics Program of the Teacher eLearning Project

by

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Executive Summary

The Learning Partnership's Teacher eLearning (TeL) program provided a professional learning experience for grade 6, 7, and 8 mathematics teachers in the Greater Toronto Area during the 2003-2004 school year that combined periodic face-to-face day sessions with weekly online discussions and activities. This document reports on evaluation findings in five main areas: (1) the program's impact on teachers; (2) its impact on students: (3) its impact on students of different socio-economic (SES) backgrounds and abilities; (4) other intended and unintended effects of the program: and (5) issues related to the program's sustainability and transferability. The evaluation methodology included pre- and post-program surveys of participating teachers and their students, classroom observations, interviews of program leaders and facilitators, and analyses of online activities.

Findings suggest that teachers, on the whole, benefited from the program by developing greater confidence to teach mathematics; they became more committed to reflecting on their pedagogy now and in the future; they have begun to collaborate more with colleagues in some instances; they are implementing in their classrooms the three-part lesson strategy introduced during the program; they have introduced manipulatives, games, and technology into the curriculum, although in some of the classrooms in which we observed teachers failed to understand the intent of the activities or did not provide sufficient guidance to solidify student understanding; and have a greater understanding of how students learn mathematics. Teachers have also succeeded somewhat in motivating students to be more engaged in mathematics learning.

Whether student attitudes toward mathematics were positively affected by teachers participating in the program is less clear. Teachers and principals together reported that students enjoyed the mathematics activities teachers introduced from the course, and that students found them very engaging. They both saw signs of improvements in students' self esteem, attitudes, motivation, and better on-task behaviour as a result of project activities. We noted improvements in engagement, interaction, and higher level discussions in about half of the classrooms in which we observed. On the other hand, by the end of the program, significantly more students reported that they spent less time studying mathematics (as well as other subjects), they appeared to value it less, felt it is of less importance to their lives, and found mathematics more boring than in the fall. In addition, there was evidence that low SES students placed greater importance in doing well in mathematics than high SES students. Boys and ESL students were two other groups that appeared to benefit slightly more from the program.

Despite the program's successes two concerns arose. First—and perhaps the most disappointing—was the weakness of the online community. Teachers were not as engaged in posting messages to the discussion forum and contributing reflective journals as one would expect, particularly as the program wore on. And secondly, problems were encountered by

some teachers about release time they were taking for the program. These problems were related to the actual amount of time away from their students and the resultant guilt from being away from their classrooms so often, difficulties in locating and preparing for supply teachers, and dealing with annoyed parents.

We conclude with eight recommendations to enhance the program should it be offered again and for improving the science program next year. They are: (1) improve online engagement of teachers by enhancing the training of the facilitators; (2) ensure that the TeL program curriculum deals with how teachers can improve learning outcomes of all students; (3) encourage schools and teachers to plan for their supply teachers in advance; (4) urge schools to communicate to parents at the beginning of the program how teachers will benefit from TeL; (5) make the full curriculum of the program available to teachers in advance of startup; (6) include more collaborative teacher activities; (7) encourage more principal involvement in the program; (8) consider adoption of a blended learning model that consists of a summer institute and fall/winter online classes and culminating face-to-face sessions at the end of each term.

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1. Introduction

The Teacher eLearning (TeL) program is aimed at enhancing the skills of grade 6, 7, and 8 teachers of mathematics and science. It is a blended learning professional development experience that combines periodic face-to-face day sessions with weekly online discussions and activities. This document reports on evaluation findings for the program's first year that focused on mathematics and ran between September 2003 and April 2004. The report is divided into seven main sections. This first introductory section provides an overview of the evaluation methodology used by the research team. Following this, the findings for each of the five main evaluation questions are presented and discussed. The last section contains a summary and recommendations for action.

Evaluation methodology

We carried out a variety of data collection activities: including teacher and student surveys, interviews of key informants, classroom observation, and online discussion monitoring. Our methodology is summarized in Table 1.1 below.

Table 1.1 Evaluation data collection activities during 2003 and 2004

ACTIVITY	DESCRIPTION
Administered teacher and student surveys	**2003**: Teacher survey completed on orientation day in September by 68 responses; student survey completed by November 30 with 937 responses.
	2004: Teacher survey completed on last day April 1st with 52 teacher responses; student surveys completed by April 15th with 477 responses.
Interviewed principals in schools where we were observing, key school board personnel, and project staff	**2003**: Eight principals were interviewed by telephone during November; two others were contacted but not available. Four of the five facilitators were interviewed, as were two key TeL project personnel.
	2004: Nine principals and 3 supervisors were interviewed by telephone during April. All five facilitators were interviewed, as were two key TeL project personnel.

Conducted mathematics classroom observations	**2003**: Observed 17 teachers from all Boards as follows: high SES schools grade 6 (3 teachers), grade 7 (2 teachers), grade 8 (2 teachers); low SES schools grade 6 (3 teachers), grade 7 (3 teachers), grade 8 (4 teachers).
	2004: Observed 14 of the same teachers as follows: high SES schools grade 6 (2 teachers), grade 7 (2 teachers), grade 8 (2 teachers); low SES schools grade 6 (3 teachers), grade 7 (2 teachers), grade 8 (3 teachers).
Conducted evaluation forum	**2004**: All teachers participated in a half day discussion and interview session.
Online session monitoring	Throughout the program online discussions were monitored and teacher reflective journals analyzed.

Data analysis

All survey data were tabulated and statistics generated using SPSS software. The number of teachers and students included in the final data set for analysis was slightly lower than the number who completed the spring 2004 surveys because of incomplete responses or unidentifiable respondents. All interviews, including those done during the evaluation forum, were tape recorded and most were transcribed. Interview data were analyzed by searching for and summarizing common themes and patterns that emerged. Some of this analysis was done using Atlas.ti qualitative analysis software. Similar techniques were employed for the online journals and classroom observation notes.

2. Findings on Teacher Effects

Evaluation question 1: *What is the impact of the project on teacher confidence and capability to create an engaging classroom environment for their students for the teaching of mathematics?*

To address this first question we present data from the teacher survey, teacher reflective journals and the evaluation forum, interviews of principals and other key informants and our own classroom observations. We begin by describing the teachers who participated in the project.

Who were the teachers in the project?

According to our teacher survey nearly three times as many female teachers participated in the project as male teachers. The vast majority of participants (90%) held bachelors degrees, while the remainder had master's degrees. A plurality of teachers (43%) had taken some university mathematics courses, while only 5% had either a math minor or major. The rest had either some high school math (31%) or some OAC or grade 13 math (22%).

Teachers' views about mathematics

The questions on the survey were grouped into six general categories of beliefs. They were beliefs about mathematics as a subject, teaching and learning mathematics, learners, the context of teaching math, learning to teach, and technology. Here are the most notable responses to questions on these beliefs as given by teachers on the post program survey.

Mathematics as a subject. Teachers were generally quite positively inclined toward mathematics, as over half of the group (56%) strongly disagreed to a statement that math just isn't my strength and I avoid it whenever possible. A strong majority (66%) agreed with the statement that to be good at mathematics you have to remember formulas, principles, and procedures; that you have to think in a logical step-by-step manner (74%); have a "mathematical mind" (62%); and work hard at it (81%). Interestingly, even for grades 6 to 8 mathematics, some 63% of teachers felt that if a student asks them a question about math they do not need to know the answer; and about a quarter of the group felt basic computational skills and a lot of patience are sufficient for teaching elementary school mathematics.

Teaching and learning mathematics. Teachers almost unanimously felt that solving problems and understanding process were very important for students: all agreed that students should puzzle thing out themselves rather than giving them the answer to a question (98%); that the most important issue is not whether the answer is correct, but whether students can explain the answer they give (88%); and that students should show their work when solving problems (94%). They were also quite strongly in agreement that

there is no best way of teaching and that teachers have to figure out works best for them (83%).

Nearly three quarters of teachers disagreed with a statement that the range of ability in most classes makes whole group teaching of mathematics virtually impossible, although about half agreed that it is best to let students work at their own individual pace. When grouping students, just over half (54%) of teachers felt that they should avoid grouping by ability or level of performance. Teachers tended to favour differential standards for students as some 65% disagreed with a statement that the same standards should be used for all students in a class. On the whole, teachers seemed to be re-examining their practice as 77% said that they agreed with the statement that they are re-thinking their ideas about teaching.

Learners. Teachers tended to feel that ultimately the onus was on the learner to succeed or fail rather than on themselves. When asked about the source of success when students meet curriculum expectations, the main reason selected was student enthusiasm or perseverance (37%), followed by the teacher's use of effective teaching methods (25%). Likewise when students did not meet expectations, they felt it was due to student's indifference or lack of perseverance (37%), followed by failure to use effective teaching methods (21%). When working with learners from low socio-economic backgrounds, a very large majority of teachers (89%) disagreed with a statement that they should rely primarily on teacher-directed focused, whole-group instruction.

The context of teaching mathematics. The contextual questions dealt with issues such as whole group versus small group teaching and socio-economic and ability issues. Some of these topics were discussed above as there was overlap in many of the questions. One issue that has not yet been mentioned is teachers' views on classroom management. Some 71% of teachers agreed that they had few discipline problems with students, and fully 92% disagreed with a statement that they had difficulty controlling their classes. Another issue was teachers' satisfaction with their working environment. Just over half (55%) agreed with the statement that they found teaching very stressful; nevertheless, almost all (90%) teachers agreed that they usually look forward to coming to school to teach.

Learning to teach. On the job learning with the help of colleagues is often cited as being one of the most effective ways for teachers to improve their practice. The project teachers were quite divergent in how frequently they met with colleagues to discuss and plan curriculum or teaching approaches. Forty-four percent of teachers said that they met once a month or less; however, 24% said that they meet almost every day. Teachers were also asked how well prepared they felt they were to teach eleven different areas of the mathematics curriculum. Most felt they were "very well prepared" to teach decimals, percentages, and fractions (73%). They felt they were not very well prepared for most aspects of geometry: definitions and properties (52%); symmetry, transformations, congruence, and similarity (52%); and coordinate geometry (51%).

Technology use. Almost all teachers reported that their students have access to calculators (93%) and most (69%) said they allow restricted use (31% allow unrestricted use). A good majority stated that they use computers weekly or more often for making student handouts (no teachers said they never use a computer for this task). Also, of interest was teachers' responses to a question on their use of the web: a total of 27% said that they use the web occasionally, weekly, or more often for posting student work or accessing resources.

What views changed significantly during the project?

To answer this question pre and post program survey responses were compared for all 48 teachers who completed both surveys. Responses to eight questions were found to be statistically significant, indicating that their views changed during the program more than one would expect by chance alone. Without a comparison group of teachers who did not participate in the program, it is difficult to say that the changes were due only to the program. Nevertheless, given the nature of the changes that did occur one can speculate that the program was likely the most significant event that occurred during the school year that would have affected teachers' perceptions. The questions that had significant pre and post program differences are given in Table 2.1 below.

Table 2.1 Survey questions with significant pre-post program differences

No.	Question	Pre program survey mean	Post program survey mean	p[1]
7c	To be good at math you need to have basic understandings of concepts and strategies. (Strongly agree=1 to Strongly disagree=7)	1.91	2.15	.031
10a	Students should never leave a math session feeling confused or stuck. (Strongly agree=1 to Strongly disagree=7)	3.92	4.63	.000
11f	Which of the following would help you teach math…read about different approaches to teaching mathematics? (Very helpful=1 to Wouldn't help at all=4)	1.60	1.75	.018
18c	A student in your class identifies a square as a rectangle. What would you say or do? I'd ask the student, "what's a square, what's a rectangle, and try to get students to remember the difference." (Definitely do=1 to Definitely not do=4)	1.63	2.02	.012
24k	How well are you prepared to teach simple probabilities—	3.27	3.42	.005

[1] p=probability of difference occurring. When p<.05 it is assumed that the difference is not due to chance alone.

	understanding and calculations? (Don't teach=1 to Very well prepared=4)			
27f	How often do you have students work in small groups to come up with a joint solution or approach to a problem or task. (Never=1 to Almost everyday=5)	3.65	3.85	.011
33	How often do you usually assign mathematics homework? (Never=1 to Everyday=5)	4.32	4.04	.005
35d	In assessing the work of students, how much weight do you give how well students do on homework assignments? (Great deal=1 to None=4)	2.17	1.98	.029

As can be seen from the table the most significant difference was found on question 10a. More teachers disagreed with this statement on the post program survey. This suggests that the program left teachers with the impression that mathematics can be taught in a more open-ended way than they had previously thought and that leaving students with puzzling problems is acceptable. Also very significant was teachers' feeling that they are better prepared to teach probability (question 24k). This may have been because many teachers developed games on probability for the last assignment. Equally as significant is question 33, which suggests a shift to giving homework less often. Taken together with 35d, teachers seem to have the impression that homework is less important overall. No reason for this is apparent, as the program did not advocate this position. Questions 7c and 11f suggest a shift in teachers' thinking that a basic understanding of mathematics and reading about different teaching approaches to math are less important. This perception may have arisen because of teachers' greater self confidence about their teaching. (A dangerous implication could be that teachers now think that they know enough about teaching mathematics as a result of the program.) Questions 18c and 27f together suggest important changes in teacher practice as teachers now seem more skilled in questioning and have students work in groups more often. These latter changes are consistent with the eLearning program's pedagogical stance.

What changed about teachers' reflections on practice?

Throughout the program teachers kept reflective journals online that they shared with their group facilitator; they were viewable by the researchers, but not by other teachers. We analyzed the journals from all groups in all three modules, particularly noting changes that teachers said occurred in their practice. We found that teachers overwhelmingly expressed that their involvement in the e-learning program had made their own math programs more fun, hands-on, co-operative, and empowering for students. They found that classes enjoyed the Roofs and Traffic Jam activities, and that they had tremendous support and enthusiasm from students for Geometers Sketchpad. Teachers developed new uses for tangrams, geoboards, and other manipulatives in teaching intermediate students.

Many wrote about their desire to incorporate more demonstrations into their classes and also commented on future plans to incorporate storybooks into math lessons. Teacher spoke of taking students on math field trips to the Art Gallery of Ontario and the Ontario Science Center—some references were also made to "virtual math field trips," which would take the form of Webquests.

Teachers wrote about their appreciation for the ways in which the program related mathematics to everyday life—applicable and timely connections were made between it and their work. They expressed their intentions to use the student surveys introduced in the program in future classes as diagnostic tools for gauging the aptitudes and opinions of their students towards math. Several teachers commented on the usefulness of the weekly websites given in the course for providing them with activities and resources for various units and strands.

In their reflections teachers identified their desire to emphasize "the process" and not "the basics." (This was borne out in question 7c discussed in the previous section.) Teachers identified their aspiration to focus more on "why and not how," and to hone students' problem solving strategies and logical thinking skills. Many also re-committed themselves to monitoring their own self-change through continued journaling and reflective practice—some even wrote about their intention to begin math journals with students.

A third aspect of change in teacher practice was the delivery of the math lesson utilizing a three part lesson strategy. Teachers articulated their goals to implement the three-part lesson with greater success. They wrote of their desire to have less teacher directed lessons, and their wish to place greater importance on inquiry-based learning and student-centered approaches. Teachers took pleasure in learning new and fresh approaches to teaching mathematics.

Teachers who identified themselves as having weaknesses math or "math phobia" expressed gratitude for their new-found confidence in mathematics instruction. They ardently implemented new ideas and returned to unsuccessful lessons to retry them with greater aplomb—this was especially true of the module on spatial sense.

Changes reported by teachers in the evaluation forum

When asked in the evaluation forum about changes to their teaching that stemmed from the program, teachers' responses fell into two categories: improvements in their practice, and improvements in delivery of mathematics instruction. These are described next.

Improvement in Practice. Teachers spoke openly about improvements in their teaching practice as a result of participation in the program. This took many forms. Numerous comments were made to the effect that mathematics is a process as much as it is a discipline. In this way it is connected to other disciplines and must not be seen in isolation. Engaging students to reflect in math class and use language—and not simply numbers to

explain phenomena—and using language in a cross-curricular fashion were stated as being something teachers gleaned from the project. Teachers also expressed that they placed more emphasis on student communication of the problem solving process than they did the "right answer."

Many teachers shared how their confidence in teaching mathematics had been heightened due to participation in the program; they had positive things to say about how eLearning had helped their pedagogy. The following comment from one teacher summed up well what teachers expressed:

> We have been made a little more aware of how to provide a richer math lesson. We've also been reminded as well to be more aware of student directed learning and its importance. And, we are experiencing more freedom in teaching math; we don't necessarily have to follow a textbook format, we can be more creative and outgoing in our math.

Teachers noted that the process of improving practice can be overwhelming, stating that it takes considerable time to become the teacher you want to be.

Improvements in delivery. The three part lesson, inquiry based learning, technology, and games were all a part of improvements teachers garnered from the eLearning program which benefited the delivery of their mathematics lessons. With respect to the three part lesson, a teacher summarized how her colleagues felt:

> The three-point lesson formalized and scaffolded our pre-existing practices. It increased comfort levels in moving away from the text. It helped us integrate engaging activities, and gave us a greater awareness of learning styles and it gave us a wider range of activities and manipulatives to bring back to our classes.

Teachers also took pleasure in implementing technology-based learning into their mathematics programs. Said one teacher in reporting how a group of her colleagues felt:

> We enjoyed using the computers, the new technology because that's something that we don't do a lot of in our class or hadn't done in the past… The Geometer's Sketchpad for example, that was something we saw as very useful, something we think we need a lot more practise and to become more fluent with, but it could definitely become a key component in our classrooms.

Another teacher summarized well how her group's practice changed as a result of the program as follows:

> We feel that it has expanded our sense of what a good mathematics teacher is because we've been able to adopt new strategies, learn new technologies, and we've been sharing strategies by talking to other teachers that are here; we have also grown through activities that we've done throughout the project.

What changes did project implementers see in teachers?

We interviewed the project implementers, which included two project leaders from The Learning Partnership and five project facilitators, to get their opinions on teacher changes that they had witnessed.[2] The project facilitators were responsible for moderating the online discussions and leading breakout discussions in the face-to-face sessions for the same group of teachers throughout the project; the leaders were responsible for management and implementation aspects of the project. We also interviewed principals of the schools where we did onsite observations and key school board personnel who were involved in the planning and implementation.

At the beginning of the project one of the implementers, when asked about what the realistic expectations for changes in teacher practice would be, offered the following:

> I am hoping that by the end of the first year teachers are taking more risks inside of their classrooms. And that they feel that being part of the project has helped them change some of their practice…not completely, but maybe they've taken a risk to try an inquiry-based lesson on their own. Or maybe they've used something inside of the course and change the way that they taught a certain area because of something that they've gotten out of the course or something that they've learned from another teacher. Let's say that they've been in an asynchronous discussion, and they've been having a conversation and they hear that a teacher tried out this particular topic a particular way and it's not something that they would have done before this project. Then I think that [will be significant]. I don't think we are going to see a major overhaul in their practice every single day. But if we are able to hear from them that the project has helped them to change something that they do in the classroom and as a result they've had a really fabulous experience with their students, that would be [valuable]. Even if it's once or twice over the course of the school year then maybe it gets them to start thinking about teaching differently, so that to me would be a success.

From the comments in the previous section on teachers' journal reflections we can see that, indeed, these kinds of changes occurred as a result of the project. At the end of the project, implementers generally agreed that these were the kinds of teacher outcomes that were achieved: namely, many individual successes of teachers sharing ideas with colleagues and trying out new approaches. For example, the implementers frequently cited cases of teacher collaboration that did not occur before the project, but now were happening. One group of teachers from the project, with the encouragement of their principal, organized a school-

[2] Because there are only two project leaders we have combined their opinions with the facilitators to protect their anonymity and called this group the "implementers."

wide geodesic dome building activity that was reported on by a local newspaper; and another group organized a school-based intermediate mathematics contest that they hope will become a regular school event.

Several smaller scale collaborations—yet significant for those involved—were mentioned by implementers as well. Two teachers from different schools reportedly planned their final project on games mostly online using live chat. Another project was between two teachers in the same school, one in the project and the other not. According to the implementer:

> One of the teachers thought Geometer's Sketchpad was the greatest thing and another teacher in the school had used it a couple of times. So the two of them sat down and she said, "I really want to use this in my classroom," and they developed a set-up where they now rotate once a week into the computer lab and run activities on Geometer's Sketchpad, and she just thought this was the best thing in world. She said, "I have to tell you this because it's huge and I'm never going back!"

This collaboration was between a grade 7 and a grade 8 teacher, so they were also able to plan the progression of activities between the two grades as well. In another case, it was the Roofs activity that was the catalyst for collaboration. The implementer quoted a teacher as saying:

> I never talk to the teacher in the room beside me teaching the identical grade and all of a sudden we were forced to. And so we spent a lot of time talking and she said we'll continue that for sure because we have been developing lessons together or writing tests together and it has really has reduced the workload. It has really like made you feel like oh yeah, we can do this, and we can do this. And when I didn't have the expertise the two of us could kind of bash out an approach.

More generally, an implementer said that:

> I heard a lot about what teachers were doing in their own school, collaborations that they would not have necessarily taken part in prior to the project. So it may have been a school where there's one grade 6, one grade 7, one grade 8 teacher. They wouldn't plan together—they wouldn't do that kind of thing—before. And especially when we let them work together in designing their lessons with someone in their own school, they found that really useful.

What changes did principals/supervisors see in teachers?

Requests to be interviewed were sent to 10 principals of schools in Toronto, Toronto Catholic, and Durham District School Boards where we were observing teachers. Five supervisors from Toronto and Toronto Catholic District School Boards were also invited to participate in interviews regarding the project. Nine principals and three supervisors were eventually interviewed; the others either failed to respond or declined to participate.

Generally, principals were very pleased with the changes they saw in teacher practice, which they ascribed to the project. As a result students were more engaged in mathematics learning. However, only one mentioned increased use of investigative approaches or inquiry as a result of the project. Only one principal had observed no immediate changes. The principals referred to changes such as:

- Much more hands-on activity in math classes, e.g., models in 3-D geometry, manipulatives, games (6)
- More use of technology, e.g., spreadsheets, charts (3)
- More project-based instruction (1)

Principals referred to increased collaboration with others both within the school and in other schools, but were uncertain about the exact the amount of time spent by teachers on this. The release time provided by the project gave teachers time to reflect and build on their strengths both individually and with others in face-to-face settings. The respondents described some examples of collaboration that occurred:

More reflection and sharing of ideas and practices with colleagues, doing workshops at the school and board levels for other teachers, presenting ideas at staff meetings

- Teachers used the release time to meet with their grade teams in school time
- Teachers placed more emphasis on professional development in team meetings and in across-grade meetings e.g., bring and brag sharing of lessons

The principals believed that online collaboration was very limited. They admitted that they had not collected evidence regarding the extent of online interaction, but based on what teachers told them, they gathered that it was very limited and disappointing for some participants. One principal mentioned that there had been some problems with the online facilitation. Others were not sure what the causes were for the limited success.

Most of the principals (8 out of 9) were satisfied that teachers had developed skills and/or confidence in teaching mathematics using a variety of instructional strategies and materials as a result of the project. They referred to a wide range of gains made by teachers including:

- More skills to use manipulatives as part of classroom activity
- Skills and confidence in using projects related to the strands of math included in the Teacher e-Learning project
- Increased use of computers in their classrooms because they were more at ease and confident with them as a result of the project
- Providing relevant and meaningful context for student experiences

- New skills and leadership helped others in the school to understand what they were trying to accomplish

Some principals admitted they were not quite sure what to expect at the beginning of the project. Others indicated that some teachers improved more than expected and others less. Some found that the program exceeded their expectations, especially when compared with other similar professional development programs. Overall the principals were very pleased with the changes they had observed. Not one of the respondents was dissatisfied with the results.

Because they are not often in classrooms, supervisors could not shed much light on teacher changes. From second hand reports they thought that teachers were using the project as an opportunity to reflect on practice and rethink how they would teach using new approaches such as a project-based learning. Based on what they heard from some teachers, they believed that many of the things they learned in workshops were happening in their classrooms. In particular, supervisors observed that there was a lot of talk about the pedagogy, but not much about mathematics (the content). Teachers indicated they had deepened their understanding, and were very enthusiastic about using games as shown at face-to-face sessions; but their games did not indicate a growth in teacher conceptual understanding of mathematics. They thought that as a result of the project teachers were developing interest in using technology for professional development purpose and were becoming more confident about using the blended learning environment. Furthermore, the supervisors believed that the online component was not used to full advantage due to lack of teacher time and some technical failures.

What the research team observed about teachers

Shortly after the project started in the fall, the research team observed 17 teachers deliver a mathematics lesson in their normal classroom. We returned in the spring to 14 of these teachers' classrooms just as the program was ending. Three teachers we observed in the fall could not be observed in the spring because of scheduling difficulties.

Overall the observational data suggest that the eLearning program had no consistent effect on teachers' capability to create an engaging classroom environment; however, there is evidence in some cases of a positive impact on confidence. In other cases, the project led teachers to reflect on some aspect of their teaching, which may lead them to modify their practice in the future.

In seven cases, there was no discernable change in practice between the first and second sessions. We labeled these teachers A to G and they are described next.

Teachers A and B were already very knowledgeable about pedagogy and mathematical content. At both sessions they used group work, carefully planned activities, good questioning, and the three part lesson format. They set problems and tasks that focused

on important mathematical ideas and they encouraged their students to investigate, to analyze, and to compare strategies. By the first observation session, these teachers had already developed strong *communities of practice* (Wenger, 1998) in their classrooms. However, although the ideas in the modules were not new to these teachers (their main contribution to the program was probably their mentoring of less experienced participants), both teachers spoke at the second interview with renewed confidence. Each had received affirmation from the program that specific approaches that they were employing in their classrooms were consistent with the research on how children learn mathematics e.g., using literature, grouping, setting as a priority sharing and discussion of strategies. They also appreciated the emphasis on mathematics concepts, because they noted that often professional development activities are built around the latest educational idea (e.g., journal writing, group work, manipulatives) rather than focusing on helping students develop deep understanding of important mathematical ideas.

Teachers C and D used methods at both sessions that incorporated some of the good teaching practices presented in the modules: students worked in groups; investigations were designed around relevant contexts; and there was awareness of the importance of sharing. However, the investigations were sometimes poorly structured, or just disguised procedural learning, and many questions asked by the teacher dealt with superficial aspects of the mathematics. Three other teachers (E, F, and G) showed no change in approach and, in fact, espoused methods that were in conflict with the ideas presented in the modules. One prepared and taught lessons that focused on less important mathematical activities for both sessions. Another used a very traditional approach by largely focusing on teacher directed instruction for procedures (some of which were beyond the elementary curriculum). A third used group work at both sessions, but students worked on a disconnected set of problems/tasks and there was no attempt to draw students together to discuss strategies or build mathematical connections.

Although a change in practice was not evident during observation sessions for teachers C, D, E, F, and G, comments during the interviews suggest that for some of them the experience supported a shift in thinking. For example, one noted that the project has made him more conscious of helping students develop their own problem solving approaches; several found the game approach valuable; and one said that eLearning had broadened her horizons, giving her insight into mathematics and the connection between playing and learning.

In the seven remaining cases there was evidence of positive changes in practice from the first observation to the second. These teachers' changes in practice, together with their comments, illustrate a growth in confidence and in the ability to reflect on aspects of teaching. The teachers, labeled H to N, are discussed next.

Four of the teachers (H, I, J and K) took small steps; three teachers (L, M and N) made substantial gains. In the first group, three teachers used the game they had created for the

eLearning program; the fourth chose a game from the student text, noting that he had not used the activity the year before but had recognized its value after participating in the games module. Although teachers H, I, J and K did not fully capitalize on the potential of the games to help their students make mathematical connections, they did demonstrate a budding awareness of the following: that an activity must be carefully planned and orchestrated; that it is necessary to consider possible student difficulties during planning; and that the opening of the lesson needs to connect to prior knowledge and provide students with skills for the activity. All these ideas relate to lesson planning—and planning was a significant shortcoming for these teachers' lessons. Observation reports of the first sessions reveal that some of them had not allowed for sufficient time to review the skills their students would need (e.g., drawing isometric representations), most were unprepared to address student misconceptions and difficulties (e.g., with the concept of circumference), and many appeared to develop all but a few examples and questions 'on the fly'. Since, in the second sessions, these teachers were using games they had developed for the program, it is difficult to know whether any changes in practice will extend to future lessons; however, there are a few hopeful signs. Teacher H used an activity in the first session, remarking that he must always teach a concept before students do an activity (i.e., an activity is an add-on); in the second session, he used the game to introduce a concept. Teacher J commented that the eLearning experience has made him more creative and has helped him feel more comfortable in the delivery of math through activity-based learning.

The three remaining teachers demonstrated a significant change in one or more areas. One moved from direct teaching to a much more open style, and at the second session talked about her new appreciation for letting students struggle with an idea. She said that the eLearning experience "opened her eyes to not being so teacher-directed in the classroom" (teacher comment, paraphrased by observer). Another of the three, who was already confident and knowledgeable, showed in the second session that she had moved from having students share what they did, to having them compare and debate approaches. The final teacher in this group taught an adequate but unfocused first lesson. Her second session was much more tightly organized and effective. She commented that the eLearning project had made her see teaching math as a priority, and had helped her reflect on her teaching practice.

Discussion of findings about teacher changes

Looking across all of the above data sources, we can see several consistent patterns emerging about the outcomes that the TeL program had on teachers by the program's end. Foremost is the teachers' development of confidence in teaching mathematics. In and of itself, this is a significant accomplishment of the program as Graven (2003) identifies confidence development as a key component of in-service teacher learning. This confidence has made teachers more willing to experiment with new ideas, activities, and approaches in their classrooms. Even those who were already quite confident about their mathematics

teaching abilities at the beginning of the program for the most part appeared to have benefited by trying new ways of having students solve problems and by thinking more broadly about the teaching of mathematics. The confidence seems to have lead to more collaboration and sharing by some, both with other teachers across grades within their own schools and with teachers in other schools. Some teachers are now being seen as leaders in mathematics teaching in their schools, too, as a result of the program.

Another outcome is that participating teachers appear to be more committed to reflecting on their pedagogy now and in the future. This is an important shift in practice because for school reform to be successful teachers not only need to learn new skills, they may need to unlearn beliefs about students or instruction that have dominated their professional careers (Darling-Hamilton & McLaughlin, 1996). Teachers are now talking with colleagues about the pedagogy of mathematics, whereas in the past they were more likely to talk only about content. Related to this is their greater use of language in the mathematics classroom, for example, by having students describe the problem solving process they use rather than just giving the correct answer. While this is an encouraging development, it can become quite routine if teachers only have students dryly describe what they did instead of discussing the merits of their approaches.

The idea of the three-part lesson seems to have taken hold, even though not all teachers are implementing it fully. Additionally, teachers are now favouring more open-ended assignments and activity-based learning using manipulatives, possibly are more skilled in questioning, and are relating mathematics more to everyday life. We are puzzled, however, by teachers' apparent devaluing of homework as indicated by the survey results. This could be interpreted as a positive development in that perhaps teachers now understand that tasks must be meaningful and they may realize that the work they had been assigning was "busy work." While there is a need for practice in mathematics, it could be that teachers are including this more in class now. We put forward this idea because in the next section, where student survey results are discussed, responses indicate that students are doing starting more homework in class.

Teachers' ideas about how students learn appear to have undergone a transformation as a result of the program. They believe that students can learn in a more open-ended way than they had previously thought and that leaving students with puzzling problems is acceptable. There also is evidence of teachers having students work more with each other in groups. Another related finding is that more teachers are having students engage in debates about what the correct solution is to a problem, rather than answering the question for them.

Lastly, teachers also developed technology skills due to the program. Most prominent is how well they liked using Geometer's Sketchpad in the classroom because of the very positive student response to this tool. They became comfortable with the use of the Internet for professional development: for example, searching for resources on the web, taking part in online discussions, and participating in synchronous chat sessions.

3. Findings on Student Effects

Evaluation question 2: *What was the impact of the program on students as demonstrated by their classroom engagement and perceptions about mathematics?*

Although the TeL program was directed at teachers, the expectation was that by introducing improved activities, resources, strategies, and ideas into the mathematics class, students would benefit. We examined this question through a student survey, an analysis of teachers journals and the evaluation forum transcripts, principal and key informant interviews, and our own classroom observations. We begin by describing the students who were in the participating teachers' classrooms that we surveyed.

Who were the students in the project?

The 427 students who completed the fall and spring surveys were almost equally distributed across grades 6, 7, and 8. A large majority reported getting A's (80-100% grades) and B's (70-80% grades) in mathematics over the last two years. Over 74% of students said agreed or strongly agreed that they enjoy learning mathematics. Forty-one percent of the students report that they spend on average one to two hours per week working on mathematics, 25% spend less than one hour, 21% spend three to five hours, with the remainder spending either no time (2%) or more than five hours (10%). Students in the project have ambitious educational goals, as nearly three quarters felt that they want to attend university after they finish school; slightly fewer (65%) would like to have a job that involves math. Almost all (99%) agreed or strongly agreed with a statement saying that it is important for them to do well in math, while slightly fewer (84%) believed that mathematics is important for their lives. Likewise 98% reported that their families also believe that they should do well in math.

How did students' views about mathematics change?

We compared the results of the fall and spring student survey on mathematics to see how students' views changed. As noted with the teacher survey, it is difficult to attribute the Teacher eLearning Program to changes in students' attitudes because there was no comparison group of students. Nevertheless one can argue that most of the observed changes—which are described below—do seem to be logically related to the program. Overall, we found that 27 questions of interest had statistically significant differences between the fall and spring.[3] We grouped these questions into four categories for ease of discussion: time spent on mathematics; the mathematics classroom; value of mathematics; and succeeding in mathematics.

[3] Because the sample size for the student survey is larger than the teacher survey, it is easier for statistical differences to be found. Even though statistical differences are found whether the differences are educationally meaningful is open to debate.

Time spent on mathematics. Students differed between fall and spring on four questions related to time spent on mathematics as illustrated in Table 3.1 below. Questions 4g and 3 suggest that students were spending *less time* working on mathematics in the spring than they were in the fall. This seems to be part of a trend to spending less time studying overall because responses to question 4h which indicate students spend less time in other subjects as well. Students may be filling this void with more socializing because their response to question 4c suggests that they were spending *more time* playing or talking to friends outside of school, and more think it is important to have time to have fun (10b and 11b).

Table 3.1 Survey responses about time spent on mathematics

Quest. No.	Time on spent on mathematics questions	Fall Mean	Spring Mean	P
3	Total amount of time in one week usually put into mathematics. (No time=1 to More than 5 hrs=5)	3.28	3.13	.009
4c	The total amount of time in one day that you usually spend playing or talking with friends outside of school. (No time=1 to More than 5 hrs=5)	2.67	2.80	.020
4g	The total amount of time in one day that you usually spend studying mathematics or doing mathematics homework after school. (No time=1 to More than 5 hrs=5)	2.45	2.34	.007
4h	The total amount of time in one day that you usually spend studying or doing homework in school subjects other than mathematics. (No time=1 to More than 5 hrs=5)	2.77	2.64	.005
11b	I think it is important to have time to have fun. (Strongly agree=1 to Strongly disagree=4)	1.46	1.38	.013
10b	Most of my friends think it is important to have time to have fun. (Strongly agree=1 to Strongly disagree=4)	1.48	1.41	.040

The mathematics classroom. Responses to questions 19b and 19f in Table 3.2 suggest that teachers are trying to make the mathematics classroom more relevant to students as more students agreed in the spring than the fall that new topics are introduced with examples of the relevance of the topic. In the spring students reported doing less textbook work (Q8a) and more exercise sheets (Q8b) than in the fall. Project work seems to have dropped off in the spring (Q8c), but student writing on the board increased (Q20q). Students

perceived that they wrote more quizzes and tests in the spring than the fall (Q20c), which could be an artifact of grade 6 students writing EQAO tests.

As for homework, students report that in the spring they had a greater opportunity to begin the homework in class (Q20k), and that their teacher checked it less often (Q20j). Whether as a consequence of less teacher checking or not, *fewer* students appear to agree with the statement in question 9a that most students in the class do their homework.

Students appeared to be using computers and calculators *more* in the spring than the fall (Q20g and Q20f), although the Web seems to be used *less* for mathematics projects than before (Q16b). Teachers are also using the overhead projector less (Q20p).

Table 3.2 Survey responses about the mathematics classroom

Quest. No.	Mathematics classroom questions	Fall Mean	Spring Mean	P
8a	In my mathematics class students often work using a textbook. (Strong agree=1 to Strongly disagree=4)	1.96	2.06	.007
8b	In my mathematics class students often work from exercise sheets to practice what the teacher has taught. (Strong agree=1 to Strongly disagree=4)	1.88	1.78	.010
8c	In my mathematics class students often work on projects. (Strong agree=1 to Strongly disagree=4)	2.57	2.78	.000
19b	When we begin a new topic in mathematics, we begin by discussing an example related to everyday life. (Almost always=1 to Never=4)	2.40	2.24	.003
19f	When we begin a new topic in mathematics, we begin by trying to solve an example related to the new topic. (Almost always=1 to Never=4)	1.98	1.81	.001
20q	How often…students write on the board. (Almost always=1 to Never=4)	2.61	2.49	.013
20c	How often…have a quiz or test. (Almost always=1 to Never=4)	1.87	1.79	.064
9a	In my mathematics class most of the students do their homework. (Almost always=1 to Never=4)	1.98	2.07	.008
20k	How often…begin homework in class. (Almost always=1 to Never=4)	1.62	1.53	.042

20j	How often…teacher checks homework. (Almost always=1 to Never=4)	1.66	1.79	.006
20g	How often…use computers. (Almost always=1 to Never=4)	3.40	3.31	.045
16b	How often used the World Wide Web to access information for mathematics projects. (Almost always=1 to Never=4)	2.94	3.11	.003
20f	How often…use calculators. (Almost always=1 to Never=4)	2.38	2.04	.000
20p	How often…teacher uses an overhead projector. (Almost always=1 to Never=4)	2.53	2.70	.001

Value of mathematics. Unfortunately, students did not seem to value mathematics as much in the spring as in the fall as fewer agreed with statements that mathematics is important in their lives (9e) and that it is important to do well in mathematics to please themselves (Q18d). Also disheartening is that more students agreed in the spring than the fall with a statement that mathematics is boring (17b). The one hopeful sign is that more believed in the spring than the fall that it is important to do well in mathematics at school (11a). Mean student responses are given next in Table 3.3.

Table 3.3 Survey responses about value of mathematics

Quest. No.	Value of mathematics questions (STRONGLY AGREE=1 TO STRONGLY DISAGREE=4)	Fall Mean	Sp Mean	P
9e	In my mathematics class, most of the students think mathematics is important for their lives.	1.76	1.85	.045
11a	I think it is important to do well in mathematics at school	1.34	1.27	.014
17b	Mathematics is boring	2.80	2.68	.019
18d	I need to do well in mathematics to please myself	1.60	1.68	.038

Succeeding in mathematics. Significantly fewer students agreed in the spring than in the fall that in order to succeed in mathematics you need lots of natural ability (Q13a) and good luck (13b). More *disagreed* in the spring that to do well you need to memorize the textbook or notes (Q13d), which may suggests that more students see that understanding is an important aspect of success in mathematics. This is illustrated in Table 3.4 below.

Table 3.4 Survey responses about succeeding mathematics

Quest. No.	Succeeding in mathematics (STRONGLY AGREE=1 TO STRONGLY DISAGREE=4)	Fall Mean	Spring Mean	p
13a	To do well in mathematics at school you need lots of natural ability	2.31	2.40	.039
13b	To do well in mathematics at school you need good luck	2.98	3.08	.035
13d	To do well in mathematics at school you need to memorize the textbook or notes	2.32	2.46	.007

How teachers viewed student changes

Teachers did not give many specifics in their journals about how students' attitudes and engagement changed as a result of the project. However, it is clear that students enjoyed activity-based challenges, and the inquiry-based learning opportunities afforded by the e-learning program. The Roofs activity was identified as being successful in engaging both strong and weak learners, and Traffic jam was enjoyed by teachers and students as a valuable learning opportunity. A very positive reception was given to activities in Module B; the use of manipulatives and Geometer's Sketchpad were highlights. Teachers reported greater confidence, and increased enthusiasm towards math with the use of Geometer's Sketchpad. They observed that students enjoyed playing and learning at the same time.

In the evaluation forum teachers made comments about students in two areas: initiatives students enjoyed and changes they noticed in the attitudes and abilities of students.

Enjoyment of mathematics initiatives. Geometer's Sketchpad again was highlighted. Teachers commented that it allowed students the ability to work at their own pace and have fun; teachers shared that students were very engaged with this program and were "laughing" in math class. This was overwhelmingly something students really enjoyed. Students also enjoyed the used of tangrams and manipulatives like the geoboards, which allowed them to see the "why" of math—and teachers noted that their students were more successful both during and after the lesson in retaining their learning. Classes liked taking the online research survey and were enthusiastic about being asked their opinion of math. In general there was greater reception of mathematics by students; teachers attributed this to the fact that their delivery was making mathematics more fun and engaging for a diverse group of learners.

Changes in attitudes and abilities. Teachers noted better engagement from students with lower skills as well as improvements in students' self esteem, motivation, and engagement. They spoke of increased enjoyment of math: they felt that students took greater

enjoyment from the lessons, and this in turn manifested itself in better focus during the lesson, more self management by students, and a greater willingness to take risks. One respondent noted that they observed students becoming more leadership oriented as a result of the program initiatives:

> Students are becoming advocates for themselves…through activities because they can access their partners, and sometimes they ask for calculators and manipulatives and other things that make them more comfortable in their learning…[in the] activities there are higher-level thinking skills being used as students are being asked to solve a problem. They can do it using different strategies and in different ways; and any approach is satisfactory as long as the students are continuing with the goal of solving the problem.

Of particular note were comments that indicated that certain learners were benefiting from the program. Teachers shared that ADD and LD students been able to focus longer periods of time. Also, teachers felt that there was increased learning for bodily kinaesthetic learners in activities like Traffic Jam. Students had who are tactile learners got to work more with their hands and apply mathematics skills through the creative use of manipulatives. And finally, teachers felt that all learners demonstrated greater collaborative skills, higher order thinking skills and enhanced problem solving skills.

What principals and implementers said about student changes

Most principals indicated that they had little hard evidence to "prove" that the project had affected student achievement and looked forward to later this year or next year when they expected to see the results more clearly. However, they pointed to changes in the classroom environment with the students more engaged and excited about mathematics as an indicator that should lead to improved achievement. For example, one mentioned that students are more comfortable using computers which, in turn, motivates them to complete their work and try new things. Three principals referred to improved EQAO scores for grade 6 students this year, and one attributed this to the teacher's use of new approaches from the program which make children more interested in mathematics. One felt that increased diversity in evaluation as a result of the increased variety of instruction would give a better evaluation of student achievement.

All but one principal reported that student attitudes towards mathematics improved significantly as a result of the project. They felt that the students who had often entered the mathematics classroom with a negative attitude—which often lead to misbehaviour and underachievement—were turned around as a result of the project. Their comments included the following:

- Students have shown very positive attitudes to math and exhibited better classroom behaviour

- There is increased participation because of more interesting approaches by teachers. (Excitement, enthusiasm and confidence in classroom activities as students were having a "blast")
- Positive comments appeared in student journals
- Students love technology—they are using more applications and there are fewer discipline problems
- There is more interest and more use of math language as students are required to verbalize in math class
- Student apprehension has been removed; students have become more responsive and show a higher comfort level with the subject
- Many students who would otherwise be apprehensive about doing mathematics became willing participants and even willing to take leadership in class

Only one of the program implementers had the opportunity to visit classrooms to observe mathematics being taught during the program. The implementer reported very positively on the experience:

> A couple of times when I went in [to a class] and students were actually working on the project [activities and] they were really excited. They were playing the games [developed by teachers as part of the program] and they had gone further than what they were asked to do and they wanted to go to the other classes and try them out and present them and do things. [The teacher] has given me very positive feedback.

Other implementers reported that they had received favourable reaction from teachers as well on student engagement with mathematics as a result of the new approaches they were taking in their classrooms. For example, one implementer reported that a teacher told her how valuable it was to conduct the student survey because of the rich discussion she had with her students about the survey results. Another talked about how teachers told her of the enjoyment students got out of working with Geometer's Sketchpad. Important to note also was the fact that no implementer received any negative feedback from teachers about the effects the program activities had on students.

What the research team observed about students

We found it difficult to determine what constitutes evidence of an impact on students. For example, students in teacher H's class were very engaged in the first session but they may have simply been enjoying the chance to collaborate, since the teacher admitted that he doesn't usually have students work in groups. On the other hand, students in teacher E's grade 8 class were actively engaged and focused in both sessions—but the tasks involved only simple arithmetic. Thus, we will use "engagement" to mean, "actively, and

enthusiastically engaged in mathematical activities that reflect the ideas presented in the modules."

Using this definition, the observational data suggest that there was no change in six classes. In three cases, the teachers (A, B, and D) were already using appropriate techniques, and helping students to see: (1) that mathematics is interesting; (2) that they can make sense of mathematical ideas; and (3) that sharing and discussing strategies is a vital part of the process. There may have been small changes in student participation and attitude, but these were not evident to the observers. On the other hand, in 3 cases, (teachers E, F, and G) lessons were very teacher directed, fragmented (i.e., students worked on unrelated tasks), and/or poorly planned. Students worked diligently and in some cases with considerable enthusiasm, however, the activities did not reflect the ideas presented in the modules.

In seven other classes there was some evidence of change. One sign was increased student interaction during the second session. This was evident in the classes of teachers C, H, I, K, L, and N. Another sign was active involvement in debating the merits of particular answers or strategies (e.g., class of teachers M and N). However, although students were more involved in the second session, in several cases (e.g., class C) the teacher was still tentative about the new methods and failed to give sufficient guidance to help students solidify their understanding. (We were unable to comment on the class of teacher J because the observations for session 1 and session 2 were conducted by different members of the research team.)

One final observation that we had was about something that *did not* happen in most cases: at the initial session there was no student mathematics work on display in the classrooms, although there were many posted examples of student stories, social studies projects, and art work. Typically mathematics displays were limited to a number line and a poster with problem solving steps. By the second session students had done extensive and interesting work (e.g., the Roofs activity, the Geometer's Sketchpad work, Traffic Jam); however, none of this work was on display. In only two classes were there examples of student mathematics and in both of these, the displayed materials were connected to an integrated art/math project. We speculate that there may be a connection between the posting of student work and teachers valuing mathematics as a creative activity, however the issue needs further research. At a more general level, however, research suggests that there is a correlation between the classroom physical environment and student self-esteem, satisfaction, and achievement (Dodd, 1997; Pierce, 1994).

Discussion of findings on student changes

The overarching goal of the TeL program is to better prepare teachers to help increase student outcomes. This is a worthy goal because research has shown that student achievement gains are more influenced by the student's assigned teacher than other factors such as class size and composition, with roughly 7% of the total variance in test score gains

attributable to the teacher (Darling-Hammond & Youngs, 2002). Furthermore, a study of the National Assessment of Educational Progress (NAEP) done by Wenglinksky (2000) found that eighth grade students did better in mathematics when they had teachers who: engage in more hands-on learning and emphasize higher order thinking; have a major or minor in mathematics or mathematics education; have professional training in working with diverse student groups; and have training in how to develop higher order thinking skills. Consistent with this research the TeL program emphasized hands-on learning and, to a lesser extent, higher order thinking and diversity. Therefore, one should reasonably expect some influence from the TeL on students. Our finding about the program's influence are quite mixed, however.

By the end of the program, significantly more students reported that they spent less time studying mathematics (as well as other subjects), they appeared to value it less, felt it is of less importance to their lives, and more boring than in the fall. Overall, this paints a fairly discouraging picture of students' thinking about mathematics. Unfortunately, our research design did not have a comparison group of students whose teachers were not in the program. So we have no way of telling whether this is a typical decline in student attitudes, or if the program helped stem the tide of the typical attitudinal pattern for middle school students. Alternatively, it could be that students think of mathematics as "sums" and other rote work, and when they responded to the survey did not think of the games and activities introduced into their classes as "math."

On the more positive side, students said that teachers were using more relevant examples in the spring than the fall, and that they believed that success in mathematics can be attributed less to natural ability, good luck, and memory (and presumably more to hard work and understanding). They also reported using the textbook less, using more exercise sheets, and writing on the board more often. These may be viewed as positive developments because: (1) the textbooks are old and do not address the new curriculum or methods; (2) the move to exercise sheets shows that teachers are looking elsewhere for materials such as those from the program and the Internet; and (3) that writing on the board more suggests more student involvement in the lessons.

Teachers and principals together reported that students enjoyed the mathematics activities teachers introduced from the course, and that students found them very engaging. They both saw signs of improvements in students' self esteem, attitudes, motivation, and better on-task behaviour as a result of project activities. Our classroom observations were less sanguine. We saw in about half of the classes improvements in engagement, interaction, and higher level discussions, however there were problems in some of those cases of teachers failing to understand the intent of the activities or providing sufficient guidance to solidify student understanding.

Therefore, on the basis of evidence from teachers, principals, and from our own observations, students were more engaged in mathematics as a result of the program, but we

do not have data on how widespread this engagement actually was. This greater engagement did not appear to translate into improved attitudes toward mathematics, however, unless one accepts the position that students' survey responses were about the traditional rote mathematics and not about the new activity-based program that teachers introduced.

4. Findings on Differential Effects

Evaluation question 3: *Did some students benefit more from the program than others?*

One of the six fundamental principles for school mathematics articulated by the National Council of Teachers of Mathematics is that "mathematics education requires equity—high expectations and strong support for all students" (NCTM, 2000, p. 2). The document continues:

> All students, regardless of their personal characteristics, backgrounds, or physical challenges, can learn mathematics when they have access to high-quality mathematics instruction. Equity does not mean that every student should receive identical instruction. Rather, it demands that reasonable and appropriate accommodations be made and appropriately challenging content be included to promote access and attainment for all students.

Thus knowing how students with diverse backgrounds responded to the teaching ideas and strategies introduced by teachers in the program is critical to fully understanding its impact. Since the program drew upon teachers from teachers from high and low socio-economic status (SES) schools, our primary concern was to see if learners in low SES schools derived more or less benefit from their teachers' participation in the program than those in high SES schools. Also of interest was to see if there were any differences between genders and between special needs students and the mainstream. The two main sources of data to address this question were the student survey and teacher observations.

Student survey responses in high and low SES schools

We compared student survey responses in high and low socio-economic status (SES) schools to the 27 items on which students differed significantly between fall and spring. These items were shown in Tables 2 to 5 in the previous chapter. To conduct this analysis schools were categorized as either high or low SES according to information provided by the school boards. Several schools in the study were of mid SES and, therefore, were not included in this analysis. This reduced the number of responses to 373 (n=216 for low SES; n=157 for high SES). Students in each grouping responded differently to six of these items.

Three of these differences concerned amount of time spent working on mathematics. High SES students reported spending significantly less time on mathematics work in one week than low SES students (Question 3; p=.020); less time studying mathematics or doing mathematics homework after school (Question 4g; p=.012); and less time on other school subjects (Question 4h; p=.0004). The means for Question 4g, which are illustrated in Figure 3.1 are of particular interest as they indicate that the decrease from fall (time =1) to spring (time =2) was relatively minor for low SES students (SES=1), but substantial for high SES students (SES=2). Similar trends were found for the other two questions.

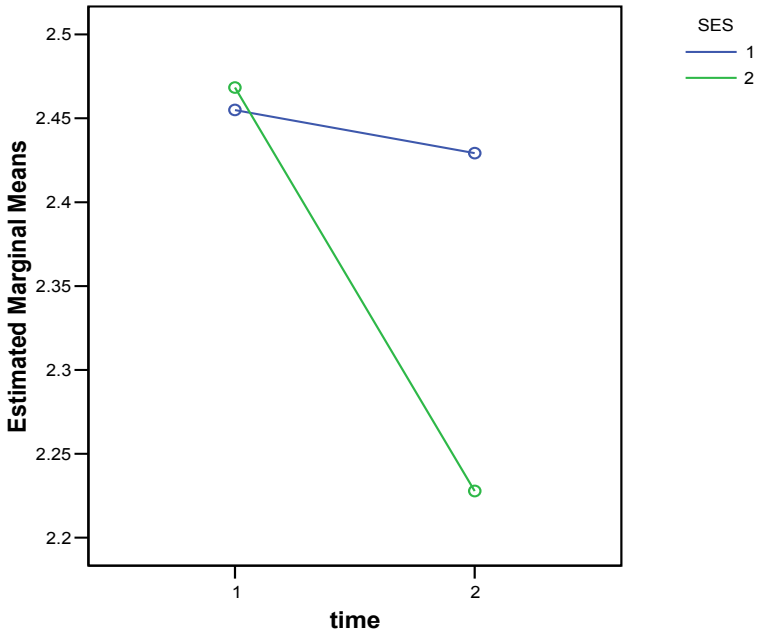

Figure 3.1 High (2) and low (1) SES student means in fall (1) and spring (2) on time spent on mathematics

Also of interest were the significant differences in responses to the question on whether students think it is important to do well in mathematics (Question 11a; p=.000). In the fall more high SES students than low SES students agreed with this statement. In the spring, this pattern was completely reversed as shown in Figure 3.2 below.

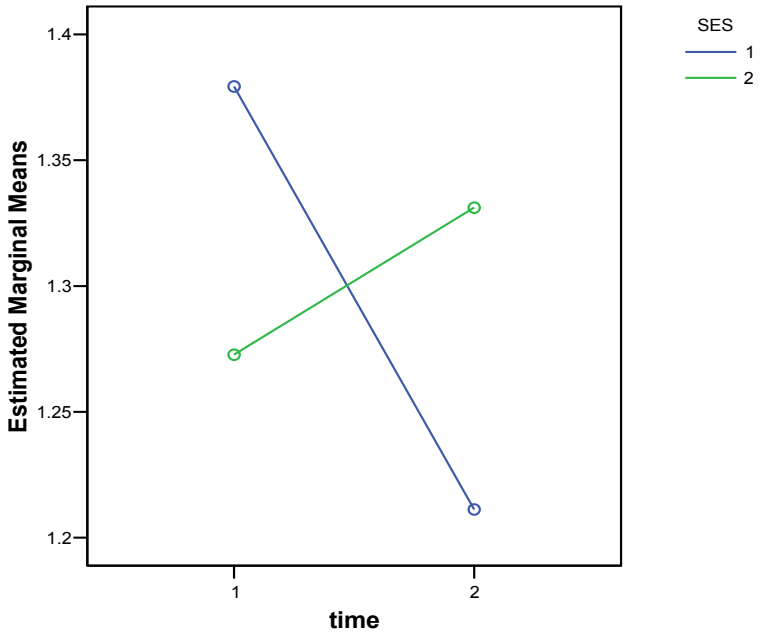

Figure 3.2 High (2) and low (1) SES student means in fall (1) and spring (2) on importance of doing well in mathematics

The two other items where the student groups differed significantly were related to educational resources: high SES students reported using textbooks less often than low SES students (Question 8a; p=.008); and high SES students used calculators more often (Question 20f; p=.002).

Teacher observations on meeting diverse needs

Teachers made mention in their journals of challenges they experienced meeting the needs of diverse learners, particularly those in lower SES schools, although there were not a large number of comments on this topic. In these schools teachers reported that students were frustrated with them being absent frequently because of the program. The disruption of classroom routine was seen as a barrier to student learning. Teachers also mentioned challenges with the inclusion of more activity based learning. They stated that implementation of initiatives such as the Roofs activity and the inquiry-based portion of the three part lesson was difficult due to the special needs of IEP students. Due to learning difficulties and behavioural problems, teachers also frequently needed to modify and adapt activities. They expressed exasperation in having to do this because of timing, lack of resources, and classroom management issues. Despite this, teachers wrote of their commitment to a hands-on interdisciplinary approach. They advocated open-ended questions; a slow and steady pace to ensure success; the maintenance of a non-threatening, risk encouraging classroom for all students; and the use of manipulatives in teaching mathematics. Geometer's Sketchpad was also seen as a vital tool for diverse learners.

More detail on this topic was provided by teachers during the evaluation forum because they were specifically asked to comment on it. Teachers articulated that peer group work (that was encouraged by the program facilitators) was a successful strategy for struggling students, and ESL students were able to excel when given the support of their teacher and peers. This was in contrast to the home environment where students did not receive the same support. This was shown to be true in both high and low SES schools. Said one teacher:

> The lower end kids, the ones that are not up to par…know they have the support of their peers or me … and they don't want to take it [mathematics work] home to do it. They say that their parents can't help them, they don't understand how. They tell them that they don't know how to do this kind of math so they get discouraged at home because a lot of their parents are not from here, have not gone to school here, have not learned here…And [students] have everything [at school] like the manipulatives, calculators… whatever they need.

A connection was made by teachers between students whose parents are able to sit down and spend time with them on homework at home, and those students whose parents could not: students who receive support in the home are more successful.

There was a general consensus that special education students, students with exceptionalities, at-risk students, and ESL students seemed to have greater confidence, and made an effort in math class when program activities were presented. The program activities brought out the reluctant learners; teachers attributed this to the fact that the math activities were a new avenue for [reluctant learners] to learn mathematics. Open-ended and fun, the activities allowed students a chance at being successful where they have failed so often in the past. The activities also helped students to explain their thinking and work on collaborative skills, and they lent themselves to extension work for the good math students: teachers explained that they were able to create an environment in the classroom where all types of learners felt included.

Some teachers spoke to gender differences, reporting that boys were more engaged in math lessons which incorporated the use of hands-on activities. One teacher expressed this observation well:

> Boys seemed to be more motivated with the hands-on activities. Girls sort of took to various tasks a lot easier whether it be pencil/paper or hands-on whereas the boys not necessarily keen on the paper/pencil but when they were presented with the collaborative or the small group activities or the inquiry-based activities they took to that a lot better than they would have been in the past.

Finally, equity of access to technology emerged as somewhat of an issue for both teachers and students. Schools without a computer lab found that fully participating in the program was a great challenge. Teachers experienced frustration when trying to implement

activities like Geometer's Sketchpad as students had to be parceled off to separate classrooms throughout their school and work independently of their teacher. This activity, which took some classes one period to complete, took much longer in schools where students had to be rotated through available computers. Additionally, teachers in rural schools reported difficulties with participation in the online component of the program as high speed internet access was not available in their area.

Observations of others

Others who were not directly involved with students had little to comment on this question, except for principals. Principals, as a whole, did not believe that SES was a factor in determining the impact of the program on students; however, they did add a few qualifying comments that deserve mention. They observed that: the program helped immigrant students to overcome initial language difficulties in learning math by using hands-on approach; students from higher SES communities who had computers at home may have benefited slightly more from the program; and parents who expressed concerns about teacher absence for the program were mainly from upper middle class neighbourhoods. On this later point, one implementer confirmed this observation and went on to speculate that students from low SES schools may have benefited slightly more because teachers in those schools did not have to bear stress from parents. As a result they "went back and tried out the different things with the students without having to think twice about it."

Discussion of findings on differential effects

Our findings on the student survey were somewhat surprising with regard to time spent on studying mathematics. We saw in our analysis of the data for the second evaluation that the amount of time spent by students reported studying for mathematics as well as for other school subjects actually decreased from fall to spring. When these data were analysed according to SES, we found that low SES students did not drop nearly as much as high SES students. Even more surprising was the substantial reversal in student opinion about the importance of doing well in mathematics between high and low SES students from fall to spring. The attitudes of low SES students actually increased over that period. A tentative conclusion one might reach is that the TeL program classroom activities and teaching strategies may have benefited low SES students more than their high SES counterparts.

We did not conduct any analyses along other social or gender dimensions, teachers seemed to agree that special education students, students with exceptionalities, at-risk students, and ESL students seemed to have greater confidence and made an effort in math class when program activities were presented. Their opinion about the value of the activities for ESL was supported by the principals as well. The only other differential effect observed was by teachers was that boys seemed more engaged than usual with hands-on mathematics activities.

5. Findings on Other Issues

Evaluation question 4: *What other issues arose in the Teacher eLearning Program?*

All of the data gathered to address the previous three evaluation questions were analyzed to determine if there were any other outstanding issues that arose in the TeL program. We identified two other prominent issues that have not yet been addressed—the quality of the e-learning experience for teachers and teacher release time. These will now be discussed in this section.

Quality of the e-learning experience

Teachers had mixed reactions to the online learning experience, with some enjoying it and participating regularly, and others participating erratically or entirely dropping out from the online component. Perhaps the best indicator of commitment to online participation was the regular posting of journals as this activity required time and thoughtful reflection. Across all three modules 69% of the teachers posted two or more journals per module. Of the remaining 31%, a large majority did not post a journal at all. Only three teachers posted a journal for each of the 14 weeks for which one was asked. This represents a relatively weak participation rate, especially when one considers that teachers were provided with one-half day per week release time to work on this and other program activities.

A closer examination of the participation data shows that the mean participation rate across all five sections into which teachers were grouped dropped as the course progressed from the first module to the third. This is shown below in Figure 4.1, together with the highest and lowest section participation rates for each module.

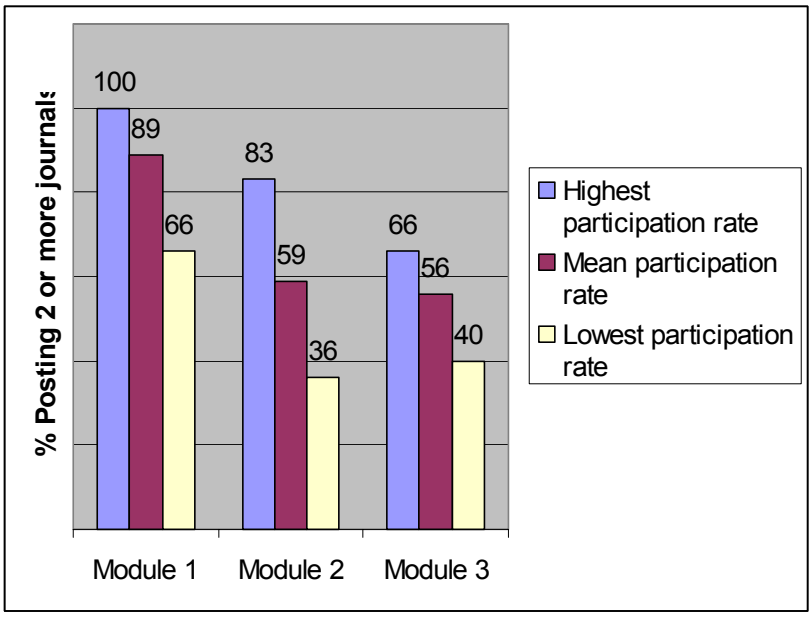

Figure 4.1 Participation rate in online journals

In general, we found that the extent to which the facilitators actively commented on teacher journals and posted responses to teachers in the discussion forum was somewhat related to participation rate to i.e., the greater the facilitator involvement, the greater the teacher participation rate. Two of the five facilitators were quite active in responding to teachers. In these sections teachers were eager to share and reflect on their teaching practices and most teachers participated fully in the first module. As time went on the quantity of postings decreased, but not the overall quality. One of these two facilitators was less active in the second module, but resumed being active in the third module. We noted that as a result teacher participation dropped and then increased concomitantly.

On the other hand, in the other three sections, the facilitators posted only a few times or not at all. In these sections we saw a pattern whereby teachers began posting enthusiastically. Then as the first module wore on teachers began dropping out, and by the time of the second and third modules only a core of a few teachers continued to post journals and comments regularly. Particularly disappointing was that three teachers who had the richest postings in the first module did not participate in journaling at all for the second and third modules. One of these facilitators reported deliberately choosing only to monitor, not post comments (except for once), thinking that commenting was not an appropriate role for facilitators.

Evaluation forum comments. When teachers commented during the evaluation forum about the quality of their online experience, they felt there was a lack of community and communication in their online sections. While they knew each other's faces they did not even know all the names of other teachers in their section. A common comment was that it is difficult to share with strangers!

Teachers attributed the absence of community to a lack of direction on the part of facilitators. This was particularly true of the online chat sessions. Many teachers reported not getting anything out of them. Similarly a lack of feedback in the online journals disengaged participants from their groups and each other—many did not see the purpose of the journals:

> The one thing I found about [the online discussions] was that I get all these ideas and I do some writing and stuff and then press the button and it goes. Mentally it goes out there somewhere. I don't know does anyone see it? No response: does anyone care?

The evaluation forum was held before the culminating game development activity, so teacher perceptions about the value of the online environment for collaboration may have changed during the interval in between even though participation did not increase.

Research team observations. When we spoke to teachers during classroom visits some initially talked about computer problems, mainly about comfort level and lack of experience which hindered their involvement. Some were exasperated due to the poor participation by many in journaling, lesson planning, asynchronous section activities, and especially online chats. More experienced users who participated in the pilot articulated frustration with chat

sessions, too, as they said they "got nothing out of it." In general, participants identified the need for greater presence of moderators in chats, and more accountability in participation at all levels in the online community.

Teachers expressed dissatisfaction for the collaborative lesson when their partners were online. Participants whose partner was a colleague at the same school however, wrote positively about the experience—they enjoyed the element of sharing and creating together. The presentation of math games during the last face-to-face session was a highlight by all accounts. Teacher articulated their want to have more opportunities in which they could share best practices during face-to-face sessions. They saw this as integral to community development.

In terms of teachers' use of eCollege, by the second session most we talked to had given up on the journaling and chat sessions. One teacher noted that the journaling and the chat components were not to be taken seriously because they lacked follow-up and feedback. Another commented that the journaling was a "serious waste of time." Four teachers were very disappointed by the poor response to chat sessions; two of those teachers had enjoyed the active online sharing during the pilot.

E-mail relationships do not seem to have blossomed amongst the teachers. The email problem is partly related to the fact that many teachers do not check their email on a regular basis—days or even weeks would go by without contact in some cases. Another possibility is that teachers found e-mail unsatisfactory in building and establishing relationships as we noted above in the evaluation forum. One teacher complained that she could not ascertain from email what her partner was like in terms of philosophy, approach, and subject knowledge, so she could not begin to understand what kind of lesson would be appropriate for the two of them to plan together.

Participants also suggested having shorter chat sessions with fewer participants in the chats. They articulated the need to establish specific weekly times for online chats with the same people. They felt this would be easier than signing up for different times every time. They expressed that they were at the mercy and convenience of facilitators. Participants were left to fit into their facilitators' schedules—this was resented on the part of the teachers.

Implementers' observations. Some members of the implementation team reported that although teachers were not always participating in the online community, they seemed to be engaging in project-related work and conversations offline. They noted cases where teachers from a participating school used online documentation and suggestions to implement team ideas in their schools. This may have been the team of intermediate teachers implementing a whole department activity or two grade six teachers team teaching together, developing and trying out games and then reporting back on them at the face-to-face session as opposed to online. Some teachers told them that the online environment was a great way

to spark ideas but that it was somewhat cumbersome to always report back on what they were doing. Though teachers were encouraged to post their results and new thinking, lack of time was voiced as a concern for many teachers. They found the time to try out ideas with their students but reflecting on what happened was an extra step that was took too much time.

Release time issues

Teacher perspectives. Even though teachers were provided with one half day release time per week to work on program related activities, many did not use all the release time they were afforded. Teachers, in general, mentioned that they felt badly about being out of their classrooms, but also commented that the release time was quite necessary for participation in the program. Teachers in some schools articulated students' frustration with inconsistent routines.

Teachers in smaller schools spoke of frustration and misunderstanding on the part of their colleagues with regards to the nature of the course and their release time. Smaller schools also found it more difficult to negotiate release time, especially when there were two or more participating teachers. Said one teacher:

> Prior to the beginning of a program like eLearning principals should be more aware of the time constraints…in our school—we are very, very small—we have half the staff out for a full day session, and it means that the rest of the staff has to really pick up [the slack].

Many respondents asked that principals be better informed about the program, and share the obligations of the project and its time requirements with their staff as a whole.

A common concern amongst teachers was about supply teachers. Many teachers complained about the amount of time it takes to prepare for a supply teacher, and that some of their students did not take well to frequent teacher absences (low SES schools more often reported this than high SES schools). Another teacher said that: "It is a great program but I shouldn't have to feel guilty coming here, that's how I feel sometimes." Teachers often left students with busy work instead of deeper learning opportunities as supply teachers are not familiar with their classes. As a suggestion, teachers alluded to the fact that they would like to be able to plan for a regular supply: they felt this could be accomplished if the timetable for the program were known at the beginning of the course. In this way, a preferred supply teacher could be booked well in advance and this would benefit both students and themselves. This would also alleviate parental concerns that teachers spent too much time away from the classroom, and that their child's learning was being compromised.

Principals' perspectives. According to principals getting supply teachers was a problem because of the large number of absences for the program, especially when added to other projects and activities teachers in which teachers in their school were involved. But

the consensus was that it was worthwhile. Principals mentioned two strategies to alleviate the problem: (1) combining two half day releases to have a full day release, which is easier to manage; and (2) using alternate teacher placements, e.g., replacing the Special Ed teacher who then taught the mathematics classes.

Principals generally found minimal problems caused by the program. Some referred to the following problems:

- **Workload**. Teachers found that the additional workload due to the project was excessive at peak times such as during report cards. Principals tried to help teachers to schedule release time to alleviate this problem but recommended that planners need to find ways to smooth out the time commitments of the project, especially when teachers have other priorities. (Teachers also commented on this problem.)
- **Parental concern about teacher absence.** Although this was not a large issue from the principals' perspective, there were some isolated complaints from parents, which principals dealt with by explaining the value added by the project for teachers and students. One sent a note to parents at the beginning of the project to alert them to the project and the consequent teacher absence needed to make it work.

Discussion of findings on other issues

The quality of the e-learning experience and release time issues were two obstacles that undermined the success of the program. With regard to the quality of the e-learning experience, teachers clearly were not very satisfied with it save for a few enthusiastic and/or conscientious teachers. Undoubtedly teachers would have found the e-learning component more rewarding had the facilitators taken a more active role in online community building. Loucks-Horsley et al. (2003), in their book *Designing professional development for teachers of science and mathematics*, point out that whether in an online course or a face-to-face workshop, the facilitator can make or break the learning experience. They add that the skill and expertise of the facilitator is key in leading to deeper and more reflective learning on the part of teachers. In any given session the facilitator may be a chair, host, lecturer, tutor, mediator of team debates, mentor, provocateur, observer, participant, co-learner, assistant, community organizer, or some combination of these (Salmon, 2003). We would like to have seen facilitators assume these kinds of roles. The reasons why the facilitators as a whole were not especially active online are unclear. As mentioned above, one facilitator believed it was not necessary to be active. For the others, the reason may have simply been lack of time to commit to the role.

The second issue, teacher release time, is somewhat of a double-edged sword. One the one hand teachers wanted and appreciated release time to do their program work, but on the other hand some felt a sense of guilt for being absent so often, faced hard questions from parents and colleagues, had difficulty securing supply teachers, and found it a fair amount of work preparing for the supply teacher to take over their classes. Ideas were suggested to

alleviate some of these problems such as better communications with parents and teaching colleagues, trying to schedule the same supply teacher on a regular basis, scheduling the face-to-face sessions at times when the normal demand for supply teachers is not as great, and if the school has two teachers, having teachers them take their weekly half days on the same day of the week, one in the morning and one in the afternoon. Although the impact of teacher release time can be minimized and better procedures for securing supply teachers can be arranged, the program will continue to face these problems under the current model. In the next section, another formulation of the blended learning model is discussed that will more directly deal with these concerns.

6. Findings on Sustainability and Transferability

Evaluation question 5: *How the project can be sustained beyond the formal end and transferred to other settings?*

The findings for evaluation question 5 are critical in identifying how the Teacher eLearning initiative in mathematics can to be continued and adopted elsewhere, either locally or beyond. We present our findings from four key stakeholders in the program: teachers, principals, superintendents, and the implementers.

Teacher perspectives

Overall teachers were very appreciative of the opportunity that the program provided and expressed a desire to see it continue and adopted elsewhere. They came away with a renewed enthusiasm for mathematics and teaching, and made personal commitments to bettering themselves to enhance the learning experiences of their present and future students. Some said that they wanted to better incorporate the program modules into their long and short range plans. Several participants believed that if a summer institute were held to prepare participants for the program (instead of a face-to-face day at the beginning of term) they would be better able to achieve this goal. Teachers also articulated the need to have a program/topic outline in advance to assist them with implementation. Beyond this they spoke of three ways in which the program could be more effective in the future. These are now described.

Areas requiring greater support. Teachers identified a need for greater assistance for split classes in the program. Split grade teachers found it very difficult to implement initiatives successfully in both grades and still meet curriculum objectives.

A greater awareness about the program, its time demands, and the nature of release time is needed within schools and the greater school community. Teachers called for initiatives to reduce confusion on the part of parents, administrators, and fellow colleagues. Likewise, greater communication to participants about the course, the curriculum, and the timetable for the modules was seen as a must. Implementing, planning, and booking supply teachers could be better achieved were this suggestion to be acted upon.

And finally, teachers felt that if more face-to-face sessions could be arranged there would be more opportunities to build strong, healthy teacher communities whose influence would be experienced long after the program is over.

Meeting the needs of teachers. According to the participants, a greater focus on the assessment of inquiry based and co-operative activities needs to accompany instruction about these teaching strategies. This would aid in the implementation and adoption of these practices. In the same way, greater opportunities for teachers to share best practices are a necessity of any future endeavour. Sharing could increase both transferability and

sustainability of the outcomes they believed. Through sharing activities, like the game sharing day, teachers felt they did their best learning.

Students and future learning. As teachers learn new initiatives to aid their students in understanding and articulating their knowledge of mathematics, teachers questioned whether the strategies they imparted to students would prepare them for the next stage in their lives. Are the teaching initiatives of the eLearning program transferable to high school classrooms they asked? A suggestion was made to include high school teachers who teach Grade nine, in eLearning activities; this would help to increase understanding and communication between teachers in the elementary and secondary panels.

Principals' perspective

Principals reported on several positive changes in their schools such as increased staff interest in new approaches to teaching including ICT and more willingness to participate in professional development activities as a result of the experiences of teachers in the TeL project. However, none went so far as to say there was a permanent change in the culture of the school. One came close, saying that the project has created interest throughout the school and changed the approach to teaching math across all divisions in the school. Some other indicators that point towards a changing cultural shift in that school included the following:

- There is more eagerness among staff to move along the mathematics, science, and technology priority of a school with the addition of two confident teachers from the program to demonstrate new approaches to others in the school.
- Math remains a priority for the school with a focus on teaching in ways that get students to become more responsive.
- The staff is more collaborative, more willing to take risks and ask questions

When principals were asked about how the program had spread within their school, they said that increased awareness about the program came in a limited way through presentation at staff meetings. Participating teachers also shared with their math teaching colleagues at team meetings. Only in one school was there a report of the "marvellous" networking that occurred as teachers drew on contacts and expertise of colleagues in the program.

Most principals had not formulated definite or formal plans for next year; however several expected to speak with TeL participants soon to develop the plan and use them as a resource for next year. In two of the schools, principals indicated they had plans to acquire resources such as new computers and manipulatives that can be used in classrooms to continue the math initiative next year.

Principals agreed that the project design was sound and should be continued. They did have some suggestions for changes to some of the elements of the project including:

- Select different locations for face-to-face meetings, especially closer to the schools to reduce driving
- Increase the connection of technology to the curriculum
- Place more emphasis on performance-based testing
- Provide some follow-up for the project at the school and board level
- Avoid meetings for project near long weekends (high demand times for supply teachers)
- Do not concentrate so many teachers in a school to reduce supply teacher problems
- Include a parent component, perhaps a celebration to encourage teachers to show results
- Continue to use information from observations of teacher in the project to make improvements to the project (teachers appreciated it)
- Make an ongoing effort to get information regarding the project spread through out the schools
- Take a look at the amount of release time and smooth out the workload

Supervisors' perspective

Among the supervisors we interviewed there was consensus that the program is transferable to other schools and other subjects. One supervisor pointed out, however, that transferring the program would be the most difficult to accomplish in mathematics. This was because mathematics is more difficult to discuss online as many teachers do not have a good grasp of mathematical concepts or the language of mathematics. And word processors and e-mail do not facilitate writing down mathematics ideas such as algebraic expressions or geometric diagrams.

Supervisors said that greatest single barrier to the project being sustained and transferred to other settings is affordability. Under budget restraints, school boards will have difficulties funding costs without subsidies for facilitators and release time at the same levels as now. (They had hoped that the use of online would successfully alleviate some of the costs associated with traditional face-to-face professional development, but did not see that happening in this project.) Also, they might need to do the program in families of schools, rather than individual schools spread across the board.

The supervisors believe that the TeL model is most appropriate for developing a community of potential leaders for ongoing professional development. They said that they will use it this way in the board in the future (if budget and staff support is available), but need to look at how it is implemented more closely. They will continue to work with

participants: debriefing in June and discussing how to keep the initiative alive. In one board plans are underway to move the online portion onto the board web-based e-learning system.

Finally, when asked about recommendations to improve the program, they rated the project very highly as it now exists. But they offered the following suggestions for improvement:

- Reduce release time and/or find ways to use it more efficiently
- Do research to find the right balance between online and face-to-face learning—find out more about how teachers process ideas using face-to-face compared with online interaction
- Focus on developing the online delivery component (development of face-to-face was well done); create an online system that is easier to use for teachers
- Look honestly at the blended approach and see if it works; if so the resources can be provided
- Develop a more sophisticated instructional design based on research where the learning goals become more focused
- Focus research in the next round on the impact of the project on implementation
- Do more training of facilitators so that they can get participants more focused on goals of the project

Implementers' perspective

Being much closer to the implementation side of the program than principals or supervisors, the implementers had already begun to think about and plan how the Teacher eLearning program can be sustained. As stated by one implementer:

> The model from the perspective of all of this release time is a difficult model to sustain. I think that there is a lot of money invested in it, and I'm not sure if the school boards have the money to do something like this consistently. So that's the one thing I have a concern about.

They believe that the blended learning approach is essentially a viable model, albeit there is some fine tuning of the model needed. Indeed, some of the recommendations presented by the teachers, principals, and supervisors above are already being acted upon for the science and technology modules next school year.

The modification to the blended learning model that is being considered to make the initiative more sustainable is to launch the professional development in late August with an introductory face-to-face workshop where teachers could learn about the project—its goals, activities, and technology—and make contact with other teacher participants. A module

would be offered in the fall that culminates in a face-to-face session at the end. The pattern would be repeated in the January to March timeframe. To quote one implementer:

> I know in a number of school boards they do summer institutes. So you do your summer institute, you've built this community, let it develop during the course of the school year with the virtual component, and then bring teachers back together to re-establish the framework of the community, to focus on some key learning, and then send them back out again for the second module. That's one supply day per teacher, two, I suppose over the course of the year. And I think that's doable.

One school board—and possibly—a second reportedly are giving this model serious consideration for internal board professional development.

Discussion of findings sustainability and transferability

Our findings suggest that there is a consensus across all stakeholders that the blended learning approach is an appropriate and, possibly cost effective, way of organizing and delivering professional development. Moreover, the underlying philosophy of the approach is consistent with the literature on the characteristics of effective professional development in that it emphasizes professional development which is long-term, school-based, collaborative, focuses on students' learning, and linked to curricula (Hiebert, Gallimore, & Stigler, 2002).

None of the suggestions for improvements to the model offered by stakeholders are inconsistent with each other, except the desire for teachers to have more face-to-face time. The wish appears to be based on the need to develop a stronger community. This is a valid concern because, as discussed in previous section, the online experience did not appear to build the sense of community for which the implementers had hoped. Part of the solution to the problem lies in developing strategies for strengthening the online discussion component, as clearly school boards would be loathe to increase the amount of release time for this initiative and teachers would be reluctant to take any more than is presently available. The other part of the solution is to better structure the face-to-face days so that there is less emphasis on experts presenting activities and more on community building.

Lastly, the model of a summer institute followed by a fall and winter online sessions appears to have emerged as potentially the most sustainable blended learning model. This model, if implemented by boards, needs to be carefully examined to see if it can engender the same amount of commitment and enthusiasm as the current model.

7. Summary and recommendations

Overall, the Teacher eLearning Program clearly met its objectives. The Learning Partnership, in collaboration with the three school boards, delivered a blended learning professional development experience for grade 6, 7, and 8 mathematics teachers. Teachers benefited from the program by developing greater confidence to teach the subject; they became more committed to reflecting on their pedagogy now and in the future; they have begun to collaborate more with colleagues in some instances; they are implementing the three-part lesson in their classrooms; they have introduced manipulatives, games, and technology into the curriculum, although in some of the classrooms in which we observed teachers failed to understand the intent of the activities or did not provide sufficient guidance to solidify student understanding; and have a greater understanding of how students learn mathematics. Teachers have also succeeded somewhat in motivating students to be more engaged in mathematics learning. Whether student attitudes were positively affected by teachers participating in the program is unclear, however by the end of the program, low SES students placed greater importance in doing well in mathematics than high SES students. Boys and ESL students were two other groups that appeared to benefit slightly more from the program.

The program was not without its difficulties, although in comparison to its successes they were relatively minor. Perhaps the most disappointing aspect was the weakness of the online community. Teachers were not as engaged in posting messages to the discussion forum and contributing reflective journals as one would expect. Problems were encountered by some teachers about release time they were taking for the program. These problems were related to the actual amount of time away from their students and the resultant guilt from being away from their classrooms so often, difficulties in locating and preparing for supply teachers, and dealing with annoyed parents. More work needs to be done in refining the design of the TeL blended learning model itself to make it better fit teachers' schedules and curricula, and to make it more sustainable.

We now offer the following recommendations aimed at improving the mathematics program as well as the science and technology program to be offered next year.

Recommendation 1. Improve online engagement of teachers by enhancing the training of the facilitators. Facilitator training is critical if the online experience is to be more engaging for teachers. The training should set out the many possible roles facilitators can play and the facilitators needs to regularly share ideas and discuss their experiences among themselves. In addition, expectations should be set for facilitators such as having them respond to all journals and participate in the discussion forums regularly.

Recommendation 2. Ensure that the TeL program curriculum deals with how teachers can improve learning outcomes of all students. Our results point to the program having a differential effect on low SES students, ESL students, and boys. Moreover, some teachers mentioned that they were not able to adapt lessons to slow learners and others reported difficulty of involving special education students in the activities. Therefore, the program should help teachers in identifying groups of students who may or may not be benefiting from the teaching approaches the program promulgates. Teachers then can share their findings with colleagues and seek assistance from the facilitators in adapting their instruction to meet these needs. A further rationale is Wenglinsky's (2000) research that shows students whose teachers have received professional development in working with special populations outperform their peers by more than a full grade level in math.

Recommendation 3. Encourage schools and teachers to plan for their supply teachers in advance. Teachers that reported the fewest problems with supply teachers were those who arranged in advance to have the same teacher substitute each time they were absent from class, so we recommend this strategy. This will likely necessitate schools knowing in advance of the first face-to-face session—preferably before school starts in September—what the supply teacher demands will be.

Recommendation 4. Schools are strongly advised to communicate to parents at the beginning of the program how teachers will benefit from TeL. This recommendation is aimed at alleviating misunderstandings from parents when they find out their child's regular teacher is out of class frequently.

Recommendation 5. Make the full curriculum of the program available to teachers in advance of startup. This will help teachers plan their own curricula for the school year so that they can synchronize it with the program's so that program activities are not introduced out of sequence for teachers.

Recommendation 6. Include more collaborative teacher activities. This year the collaborations seemed to be somewhat serendipitous. Since collaborative learning is very powerful for teacher professional growth more structure and opportunities for it to occur should be considered. This could be done through deliberately breaking up the discussion groups into smaller subgroups whose members share a common interest. Or more time in the face-to-face sessions could be devoted to collaborative activities.

Recommendation 7. Encourage more principal involvement in the program. Principals must take charge of the transformation of the learning culture of schools for reform to be successful (Fullan, 2003). Therefore, they should be encouraged to meet regularly throughout the program to discuss among themselves ways of supporting teachers in implementing their ideas and promoting change.

Recommendation 8. Consider adoption of a blended learning model that consists of a summer institute and fall/winter online classes and culminating face-to-face sessions at the

end of each term. This model is likely the most viable and sustainable model in the long run because of the considerable cost of supply teachers with the current model. The model does have associated costs; however it could be integrated into existing professional development budgets if school boards are willing to reallocate resources.

8. References

Darling-Hamilton, L., & Youngs, P. (2002). Defining "highly qualified teachers": What does "scientifically-base research" actually tell us? *Educational Researcher, 31*(9).

Dodd, A. W. (1997). Creating a climate for learning: making the classroom more like an ideal home. *NASSP Bulletin*, 81(589), 10-16.

Fullan, M. (2003). *Change forces with a vengeance*. New York: RoutledgeFalmer.

Graven, M. (2003). Teacher learning as changing meaning, practice, community, identity and confidence: The story of Ivan. *For the Learning of Mathematics, 23*(2), 28 - 36.

Pierce, C. (1994). Importance of classroom climate for at-risk learners. *Journal of Educational Research, 88*, 37-42.

Salmon, G. (2003). *E-moderating : the key to teaching and learning online* (2nd ed.). New York: RoutledgeFalmer.

Santos, L., & Ponte, J. P. (2003). *An experiment in distance in-service teacher education*. Retrieved April 19, 2004, from http://www.dm.unipi.it/~didattica/CERME3/draft/proceedings_draft/TG12_draft/TG12_Santos_draft.pdf

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York: Cambridge University Press.

Wenglinsky, H. (2000). *How teaching matters: Bringing the classroom back into discussions of teacher quality*. Princeton, NJ: Educational Testing Service.