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Trading Roles: Teachers and Students Learn with Technology

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Teachers and Students Learn with Technology

Maine Learning Technology Initiative

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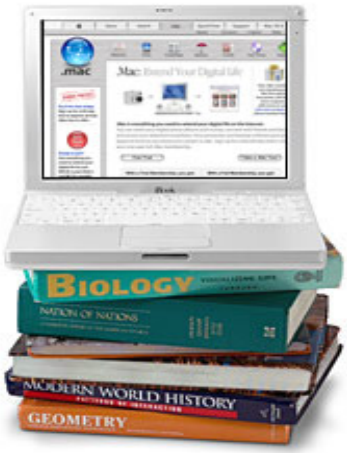

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FORWARD

Janet Fairman is an Assistant Research Professor in the College of Education at the University of Maine. Her research focuses on state educational policies and their impact on schools and classroom teaching.

The views expressed in this paper reflect the author's views and not those of any institution with which the author is affiliated.

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Trading Roles: Teachers and Students Learn with Technology

Executive Summary

The Maine Learning Technology Initiative (MLTI) is a state-wide program that provides wireless laptop computers to all seventh- and eighth-grade students and teachers. This paper describes the author's analysis of data from a state-wide evaluation conducted during the first year and a half of the program. The data include: 301 interviews with administrators, teachers, students, and parents from 23 schools across Maine; state-wide surveys of teachers, students, and technology coordinators; and 22 classroom observations from 7 schools.

The author's findings suggest that the introduction of laptops may have the potential to encourage significant and rapid shifts in the role of teachers and students in classroom learning, as well as supporting broader improvements in teaching and learning. Teachers have begun to see themselves as partners in learning with students and report a more "reciprocal" relationship with students. Teachers also report that they are shifting toward more student-centered and inquiry-based approaches, where students take more responsibility for their learning and teachers serve as facilitators. Teachers reported an improved climate for learning in the classroom, where there is more interaction and cooperative work across all groups of students and between students and the teacher. Increased communication and respect among students and between students and the teacher help to create a "community of learners."

Teachers and students reported that students have greater freedom to pose questions and research topics of interest to them. Teachers report that the laptops have helped them to differentiate curriculum and instruction, allowing students to work at different levels of depth. Teachers also report that the laptops support the use of integrated or interdisciplinary instructional approaches. Students are able to bring new content and information into the classroom, and are teaching technology skills to teachers and other students. Students typically help or teach others about technology informally, but teachers and schools have also created formal structures, such as the "i-Teams," for students to fill this role. Often, it is the low-performing and special-needs students who are teaching others about technology. Teachers' recognition of students' knowledge and skills with technology has had the impact of increasing students' self-esteem and confidence.

In summary, laptop use in the classroom appears to have stimulated a more reciprocal relationship between teachers and students, where both are valued and respected as learners and teachers. Teachers have benefited from students' knowledge and fluency with computers, and students have benefited by the opportunity to share their knowledge and skills with others. Both teachers and students have benefited socially and educationally from the broader changes in teaching and learning that the laptops have promoted within a very short period of time. The impacts of the MLTI program are consistent with and support the goals for teaching and learning envisioned by the program's developers and articulated in the *Maine Learning Results.*

Trading Roles: Teachers and Students Learn with Technology

Introduction

Across the U.S. and abroad, local and state educational agencies have developed programs to introduce laptops into classrooms in individual schools, districts, or counties. The Maine Learning Technology Initiative (MLTI) goes further than any other laptop program, in that it introduced wireless laptop computers into classrooms state-wide for all seventh-grade students and teachers in the fall of 2002 and then all eighth-grade students and teachers in the fall of 2003 (totaling almost 3,000 teachers and over 34,000 students). Evidence from a state-wide evaluation conducted during the first year and a half of program implementation indicates overwhelmingly positive impacts for teaching and learning (Silvernail & Lane, 2004). Program goals went beyond the narrow goal of teaching students technology skills to include the broader goals of encouraging higher-order thinking skills and innovation in teaching and learning, where both students and teachers learn together in the classroom (Task Force on Maine Learning Technology Endowment, 2001).

A preliminary analysis of the evaluation data revealed that teacher and student roles shifted very rapidly in the early weeks and months of program implementation, where students often became the "teachers" of technology skills and teachers were "learners." The author's analysis of the evaluation data investigated the change in teacher and student roles and focused on the following research questions: (a) What role changes do teachers and students describe as resulting from laptop use in the classroom, and what benefits do they associate with these changes? (b) How do teachers structure learning tasks differently as a result of laptop use? and (c) What broader shifts in pedagogy and instructional approach do teachers report?

Methods

Analysis for this paper is based on 301 coded interviews with administrators, teachers, students, and parents from 23 schools across Maine (see tables in Appendix), and primarily uses teacher and student interview data. The analysis also uses data from 22 classroom observations from seven schools, and responses to certain survey items from state-wide surveys of teachers, students, and technology coordinators. Data collection and analysis for each type of data is described separately.

Sample

The sample of 23 schools included nine schools that piloted the program from March 2002 through June 2002, and 14 additional schools that, like other schools across the state, implemented the program in September 2002. Most schools in the sample were either middle schools with grades 6-8 (11 schools) or were grade K-8 schools (9 schools). Two schools had grades K-12, and one school had grades 6-12 (see Table 1). Both the pilot and non-pilot schools vary by enrollment size, rural/urban location, student poverty rates, curricula, and teaching practices. Pilot schools volunteered to be demonstration sites, and could be somewhat different from other schools in the sample in that they share a strong motivation to participate in the program. One school from each of the state's nine superintendent regions was chosen by the Maine Department of Education to be a pilot school.

Interviews

Structured interviews were conducted by evaluation team members from September 2002 through December 2003. Interviews with administrators, teachers, and parents were typically done individually and lasted approximately 30 minutes to one hour. A few interviews with teachers were done in groups of two or three teachers. Interviews with students were done both individually and in groups of two or three students, and lasted from 20 to 30 minutes. Interviews with parents were done individually and lasted from 20 to 30 minutes. Key laptop team members (principals, teacher leaders, and tech coordinators) were interviewed at least twice over the school year. Some teachers were observed and interviewed twice during the school year. Most other teachers, parents, and students were interviewed once during the school year.

Interviews were tape-recorded, transcribed, and coded using *NUD*IST* (version N6) qualitative data analysis software (see Tables 2 and 3). Four members of the evaluation team from the University of Maine coded the 301 interviews around broad categories related to the impacts of laptops on: students and student learning, teachers and teaching, and school community. Further categories emerged from the process of open and axial coding of the data, resulting in 272 coding categories (Strauss & Corbin, 1998).

Interviews included open-ended questions, such as: "What is your overall assessment of the laptop program?" and more focused questions such as: "What impact do you feel the laptop program has had on: (a) your teaching practice? (b) your students?" In response to these questions, respondents volunteered their views and observations about changes in teacher and

student roles in the classroom, and changes in teaching practices. In some cases, evaluators probed these views in subsequent interviews by asking teachers if they had noticed any changes in teacher and student roles in the classroom as a result of laptop use.

For this paper, the author analyzed interview data coded as "teacher-student roles"(coded in 79 of the 301 interviews), "teacher and student communication" (coded in 97 interviews), and "students' collaboration with other students" (coded in 58 interviews), and generated additional coding for these data. Themes emerging from this analysis were organized around the research questions and were coded as follows:

Student Roles

- students helping/teaching other students with technology (formal and informal structures)
- students helping/teaching teachers with technology (formal and informal structures)

Teacher Roles

- teachers as learners in the classroom
- teachers' instructional role (facilitating or direct instruction)

Instructional Changes

- inquiry (versus memorization and practice)
- collaboration in the classroom
- individualization of student learning

Observations

The evaluation team conducted 24 classroom observations during the 2002-2003 school year in 7 of the 23 study schools. Of the seven schools, three were pilot schools. The seven schools represented four of the state's nine superintendent regions. The number of observations in each school ranged from one to eight observations (see Table 4). Lessons in five different content areas and one portfolio assessment activity were observed (see Table 5). Observations were typed on-site and lasted for the duration of the observed lessons. Two observations could not be coded for this analysis, resulting in 22 observations that the author coded by hand.

The author's analysis of the observation data generated themes similar to those emerging from the interview data. Coding categories for the observation data include those listed above for interview data, and additional categories related to the structure of learning tasks, as listed below. Table 5 shows the number of coded observations falling into different categories.

Task Structure

- Student inquiry (versus memorization or practice)
- Cooperative learning (versus individualized work)
- Student choice over topic or research questions
- Student choice over product
- Teacher rules for student web searches (open or restricted)

Surveys

The evaluation study included both on-line and mailed surveys to administrators, teachers, parents, and students. More than 26,000 student surveys and 1,700 teacher surveys were collected and analyzed by the evaluation team. Teacher surveys were mailed in the fall of 2002 and were disseminated to schools on-line in spring 2003 and fall 2003. Student surveys were disseminated on-line all three times. Principals were notified of the surveys by e-mail and through the MLTI website maintained by the state educational agency. Students took the survey in their classrooms.

For this paper, the author analyzed responses to certain items on the teacher and student fall 2002 surveys (response rate were: 33% and 44% respectively) and fall 2003 surveys (response rates: 26% and 37% respectively), and from a technical coordinator survey from spring 2003 (n = 97, response rate 44%) (Silvernail & Lane, 2004). Survey items were chosen based on their relevance to the research questions.

Specifically, the author cites survey responses to items that asked teachers about the impacts of the laptops in the following areas: teacher-student communication, student-student communication, teachers' ability to individualize curricula, students' motivation and engagement in learning, teachers' self-ratings of their own computer skills, and items asking about use of different instructional strategies. Survey data is also cited for student survey items that asked about students working in groups, where students seek help with computers, student and teacher interaction, student interest in school work, and students' self-rating of their own computer skills. Data is cited for one technical coordinator survey item, which asked about the use of students to help with technical support in the school.

Findings

The introduction of one-to-one wireless computing in middle school classrooms in Maine appears to have catapulted students into the role of "teacher" and teachers into the role of "learner" in immediate and obvious ways. Although the evaluation of the program did not fully anticipate or focus on this phenomenon, it became clear from a reading of the first round of interview and observation data that dramatic changes were rapidly occurring in classrooms on many different levels.

Within the first one and a half to three months of implementation, teachers frequently commented in the interviews and observations on how their role in the classroom had changed, as laptops allowed students to become more actively engaged in individual or cooperative learning and research activities. Many teachers also talked about the fast pace of program implementation, which limited the time teachers had to become familiar with the laptops before they had to begin using them daily in the classroom. Typically, teachers attended a two- or three-day summer orientation provided by the state educational agency, and some teachers attended further orientations in their schools.

The limited time for training prior to implementation effectively forced many teachers, who did not feel completely proficient with computer technology, to accept help from many sources in the school—even from students. As teachers scrambled to revise and implement instructional activities that incorporated laptop use, they confronted different types of glitches and complex tasks. Teachers and students needed to work fluidly across various software applications and tools, their school's server system, the Internet, and electronic mail (e-mail). According to administrator, teacher, student, and parent interviews, students became a valued source of knowledge and help for teachers and other students in the classroom, which not only increased teachers' and students' computer skills, but also created a more reciprocal relationship between teachers and students. Both teachers and students needed to learn certain things in order to effectively make use of the laptops, and both had valued knowledge and skills to contribute to that effort. One teacher's comments were highly typical of the views expressed by most teachers:

> I had an opportunity to attend the three-day training in June, so I was well prepared. What I don't have is enough technological expertise, and I feel like I have been flying by the seat of my pants a little bit in that regard, and I am learning right along with the kids, and it is just a question of giving up that control

and saying "Ok, if you guys want to use the digital cameras, you are going to have to help me figure this out." (teacher, non-pilot school, March 2003)

This section describes respondents' perceptions of change in classroom roles and instructional activities as a result of laptop use in the classroom, and evidence from classroom observations that relate to these perceptions. Interview data described here are primarily from teacher and student interviews. Proper names used in quotations are pseudonyms, and gender is sometimes changed to maintain confidentiality.

Student Roles

Students' role as "teachers" of technology generally took two forms: students helping/teaching other students in the classroom or school, and students helping/teaching teachers or other adults in the classroom or school. The lines between "helping," "showing," or "teaching" may overlap. For the purpose of this discussion, a teaching mode of activity or role included any activity where an individual (teacher or student) was either: (a) telling or showing another person how to do something with the laptop hardware, software programs, or Internet or (b) doing tasks on a laptop computer to solve another person's question or problem concerning hardware, software, or Internet use. Students' teaching role was most frequently enacted informally and sometimes through formal structures created by the teacher or school and are described below.

Students Helping Other Students

Informal structures. When asked from whom they seek help with laptop-related questions in the fall 2003 student survey, 27% of the responding students (n = 12,085) said they usually ask a friend or another student, while only 13% of the students (n = 11,708) said they usually ask a teacher. Still, 75% of the students (n = 10,486) on the same survey said the teacher is usually able to help them with their laptop. Students informally helped other students with computer-related questions or tasks in 14 of the 22 observed lessons. Informal helping/teaching occurred naturally, and spontaneously, within the course of the classroom activities, and is not unlike other instances where students help each other to explain an assignment or task. Teacher and student interviews included numerous, general and specific descriptions of students helping other students with laptop questions or problems. One teacher said: "Kids learn how to do something and then they teach other kids how to do it, which is happening more and more (teacher, pilot school, December 2002). Virtually all teachers who described students helping

with computers in their classrooms explained this activity in remarkably candid statements that both acknowledged students' generally greater comfort with computers, and the realization that teachers cannot "know everything."

> The kids really are more fluent with the machines than many of the teachers. They've grown up with them. . .They really are very good with them and they do a great deal of teaching each other how to do this and how to do that. So there is a lot of student teaching which goes on. Sometimes it's informal. (teacher, pilot school, March 2003)

> The more comfortable they feel with it, the more they are teaching everybody. I couldn't pretend to know everything that there is to know about them [computers]. (teacher, pilot school, December 2002)

Students also described helping other students: ". . . she [the teacher] figured that some of us already knew [how to perform certain tasks], and if other kids didn't know, we could help them out" (student, pilot school, May 2003). Another student said:

> We have John, who's amazing with computers. He knows everything. He's one of our eighth grade students and he knows a lot. If we can't find Mr. Smith, we're like, "John, what do we do?" . . . He's willing to help. . . and I know what I'm doing with i-Movie and stuff, so . . . people even ask me what to do. (student, pilot school, May 2003)

Typical questions or tasks with which students helped/taught other students included: printing a document, finding and using tools and software applications on their laptop, using editing tools in word-processing software, accessing a teacher's folder on the school's file server, conducting Internet searches, finding helpful websites, customizing the "desktop" appearance, and dealing with technical glitches related to hardware such as a "frozen" screen. Examples of more advanced tasks included: uploading/downloading and sending files with e-mail or the Internet; downloading graphics and inserting them into software for presentations as slide shows, i-movies, or word processing documents; and making tables or graphs for data.

Informal helping/teaching among students occurred in all lesson types—even in lessons where the teacher structured the activity in a way that emphasized individual work and minimized collaboration and student discussion. It occurred where students were seated in individual desks and where students had desks pushed together in clusters. It occurred equally in pilot and non-pilot schools. It occurred in all observed subject content areas. However, informal

helping/teaching was observed more frequently during lessons that were structured to allow cooperative learning or collaboration among students.

Different types of students engaged in helping/teaching other students about technology. Some teachers said they had one "tech savvy" student in their classroom who became the natural classroom tech guru for both students and teachers. Teachers said these students were very comfortable and familiar with computers from using computers at home, and several students made this comment about themselves in their interviews.

Yet, several teachers (at least 12) emphasized in the interviews that the students who were deemed most "tech savvy" were not always the high academic achievers, but were sometimes the low-achieving, at-risk, or even special needs students in the classroom.

> We have a kid who isn't a top student. He doesn't get all A's, but he knows a lot about computers. The other teacher on my team is not very good with technology, and she goes to him and he loves that. It's been a way for him to stand out and make a difference. (teacher, pilot school, May 2003)

> I find the kids with disabilities tend to be much quicker in picking up the technology pieces than your traditional, high achieving, academic kid. They are the ones who teach me "Oh, Mrs. Smith, this is how you do this." They are very quick. (teacher leader, pilot school, February 2003)

> I see kids in my class who are mainstreamed. They are the ones that can help me figure out a printer problem or they can help other kids when something's crashed. I mean, they are really good at that, hands-on stuff. (teacher leader, pilot school, June 2003)

> I think there are a lot of kids that would be at-risk that I've seen improve due to having a laptop. Sometimes they're the ones that are excelling on the laptop and can help with the instructors, too. I see a lot of that with the kids helping each other. (teacher, pilot school, December 2002)

Typically, students who helped other students during a lesson were not particularly tech-savvy or recognized within the classroom as classroom technology experts. Yet, these "average" students were generally able to help other students resolve tech-related problems or questions. In effect, it appeared that all students in the classroom would, at one time or another, take on the informal role of technology "teacher," while some students took on this role more frequently or were sought out by students and teacher alike, because of their recognized familiarity/skill with computers.

***Formal structures*.** Formal structures enabling students to teach/help others with technology included structures created by the teacher and by the school. Teacher created structures included:

- structuring the lesson to include cooperative learning groups or pair work, where student collaboration and discussion is encouraged;

- structuring the lesson to include formal sharing times, such as having students present the results of an Internet search or research on a topic, or allowing students to share the useful websites they found with the class;

- asking students to search for useful websites on a given topic for the teacher to review and use in an up-coming unit of study;

- asking a particular student to assist another student or group of students with technology questions or tasks or to serve as the classroom technology "expert" for the day; and

- having kids formally present/teach technology skills to a classroom of students (either the student's classroom or another classroom).

Teachers described how they enlist students to help with other students.

> I'll say, "Ann will have to help you." . . . It's a teaching and learning thing. It gives me the chance to allow them to shine. (teacher, pilot school, April 2003)

> I showed them what the next step was. Then I said, "From now on, I'm only doing this part. Next time, I am sending them to you. You need to show them the next part." . . . That gave them the responsibility. Then they could go around the room and help out, which made it nice. (teacher, non-pilot school, February 2003)

This type of formal structure for helping/teaching was observed in one of the 22 classroom observations, in a non-pilot school.

Teachers in pilot schools described how they sometimes ask students to teach computer skills in other classrooms. One teacher said, "He [special needs student] got invited to come into the regular education classroom to teach the other students and teacher how to use it [Inspiration software]" (teacher, pilot school, June 2003). Another teacher said:

> Sometimes I'll actually use a student to teach something in front of the classroom using a projector—have them come up and be the instructor. But usually it's informal and it's effective. (teacher, pilot school, March 2003)

Observers did not see students formally teaching other classrooms about technology, although three teachers in three different pilot schools mentioned this activity in their interviews.

Formal structures for students to teach technology skills that were created or endorsed by the school included:

- school-wide "i-Teams" that include students who help adults and students with laptop questions or glitches throughout the school building; and
- student leadership teams or technology clubs or focus on technology goals.

Evidence for student involvement in formal structures comes primarily from the interviews, as the evaluation team did not happen to see these activities during the classroom observations. At least 2 of the 23 study schools (one pilot and one non-pilot school) formally involved students in their "i-Teams," while most of the schools involved students in helping in more informal ways. In a spring 2003 survey of the school technology coordinators, 41% (n = 97) said they use students to help with technology support. One teacher described the i-Team as follows: "These kids . . . are trained to do a few things that they can teach their houses [teams]" (teacher leader, pilot school, May 2003). A seventh-grade student said:

> We went around and we helped with all the computers and we helped with the laptops. . . . They taught us how to use the scanner and the [CD] burner. They taught us how to go on stuff to help teachers. That's what I mainly do. I help everybody. (student, pilot school, May 2003)

An assistant principal in a small pilot school described a student leadership team's focus on computers in the school:

> We have a student leadership group here at the school, and one of their concerns now was a need to do more with the computers than just the research, the word processing, and wanting to sort of make some of those deeper connections with this powerful tool. You know, what other things are out there? And they're starting an after-school group, and we're going to try to make some connections to some other individuals in the community who are experts to see what other possibilities these things have. . . . And that was a drive from students to want to sort of go a little bit deeper. (assistant principal, pilot school, December 2002)

This type of formal structure for students was only mentioned in one pilot school.

Overall, the formal structures created by teachers were far more frequently mentioned in the interviews than were those created or endorsed by schools. Students were also observed demonstrating laptop skills to adults during school open-house meetings for parents, and some

students reportedly demonstrated laptop skills at local school board meetings. These student activities were coordinated by classroom teachers. Observers did see many instances of students helping each other by working collaboratively, sharing website information with other students and the teacher, and formally sharing what they had learned from web searches with other members of the classroom (see Table 5). Teachers asked certain students to help other students. Both teachers and students mentioned these kinds of activities in the interviews.

Students Helping Teachers

Informal structures. Students helped/taught teachers about technology in many of the same ways that they helped other students, as described above. Observers did not see students "teaching" teachers, but this could be due to any of several factors: chance; the small number of observations; the context of a formal evaluation; and the fact that the evaluation was not focused on changes in teacher or student roles. Yet, interviews with teachers and students did provide ample evidence that students were frequently performing this role in the classroom.

> My children this year already had laptops for three month . . . they help me all the time, learning things. (teacher, pilot school, December 2002)

> Sometimes I'll ask them [students to help]. It's fine, because they use the programs more than I do. I have an idea how to work it, but I need the smaller things. (teacher leader, pilot school, May 2003)

> I think many times, in the case of the teachers, that it's the car driving the person, because a lot of the times, it's the kids teaching us. (teacher, pilot school, May 2003)

> I would have to say honestly that they know a lot more about computers than I do. The technical pieces, like "How do I do this?" It has been a role reversal at times. (teacher, non-pilot school, February 2003)

In response to a general question about what impact the laptops had on his son, one parent said: "He's teaching his teacher things about the laptop, so he gets great pleasure out of that" (parent, pilot school, Feb. 2003).

Formal structures. The formal structures described in the preceding section on students helping students were also a vehicle for students to provide technology knowledge and skills to teachers. The interviews frequently mentioned that students contributed website sources they had found on their own with other students and the teacher. Some teachers specifically asked

students to look for websites for future units of study. Two math teachers described how students help to locate useful websites for math activities.

> I said, "Ok, this is what I need from you. Go searching for me. I need stuff on percent and try it out. I only want to know the website if it's good." (teacher, pilot school, May 2003)

> Believe it or not, the students fortunately have brought some really neat things in themselves. He [student] has made me a list of math [web] sites a mile long that he's found. We have used some of those. (teacher, non-pilot school, February 2003)

Another teacher said:

> They'll e-mail me sites and say "This might go along with what we're doing," which is good. It seems like I've been giving them more [unfinished sentence] . . . and I'll say "See if you can find a site or find some extra information" on whatever we're doing, and they do that. (teacher, pilot school, April 2003)

Students also helped teachers by formally presenting technology skills to classrooms (and teachers) and by resolving glitches in other classrooms as part of the school's "i-Team."

Differences in teachers' and students' technology skills and general comfort with computers help to explain the "teaching" role that students assumed within the laptop program implementation. In the interviews and surveys, teachers consistently self-rated their technology skills lower than students self-rated their skills. In the fall 2002 teacher survey, only 29% of the responding teachers (n = 704) rated their overall computer skill level as either "advanced" or "expert" (response choices ranged from novice to expert) (MEPRI, 2003). By contrast, 47% of the responding students rated their skill in word processing as "advanced" (the highest of four response choices), 52% of the students rated their skill in doing Internet searches as "advanced," and 23% of the students rated their skill in using presentation software as "advanced" on the fall 2002 student survey (n = 7,329).

In the interviews, teachers also described students' fearless attitude about exploring and using computers. Teachers generally held the perception that students were less hesitant than teachers to explore the tools and software on their laptops on their own, and that doing so helped students to quickly acquire new knowledge and skills. One teacher commented, "I think the kids have been great teachers, and they are not afraid of them [computers] (teacher, non-pilot school, November 2003). Another teacher said:

> The kids are very knowledgeable and dare to take risks far beyond what the adults would. And I think that gave me confidence that if I just went with the flow, that things would be okay. And they have. (teacher, non-pilot school, March 2003)

Although teachers described themselves as being very willing to learn from students and with students, some teachers had to overcome their initial feelings of insecurity or discomfort about being less knowledgeable than students. Teacher leaders confirmed these views in their comments about their peers, particularly about eighth-grade teachers who inherited the "experienced" first cohort of students to go through the program. Eighth-grade teachers generally had no more lead time to learn about the laptops than did the seventh-grade teachers the prior year.

> One of my greatest fears at the beginning of the year was that I'm not going to be able to teach them how to use these properly, because I'm not as proficient in it. . . . The kids teach each other and they teach me. (teacher, pilot school, March 2003)

> I did e-mail them [her students] and said, "You know, your teacher is learning slowly," and they'd send back these little faces and they'd say, "We understand, we'll help you." (teacher, pilot school, December 2002)

> A lot of times the kids know more than we do, which is nice, because it helps us out. I mean, some people are intimidated by that, but I think it's nice. It helps us out and it's empowering for the kids too. (teacher, pilot school, May 2003)

> The teachers that I work with have seen this coming . . . they're trying to get up to speed for next year. But I think too that those teachers feel like I do, that it is okay to learn from the kids. (teacher, pilot school, May 2003)

> I truly believe kids are amazing on these, and if we don't stay up with them or have a few people that can stay up with them, they'll soon go by us. (teacher, non-pilot school, March 2003)

> You don't want to look foolish in front of anybody, and we're getting over that stigma. . . . They're starting to figure out that "Okay, it's alright if I don't know everything." (principal, non-pilot school, November 2003)

On the whole, teachers appeared to have a pragmatic attitude about accepting help from both staff and students in their buildings.

Teacher Roles

Teachers from both pilot and non-pilot schools described how their role in the classroom had shifted as a result of laptop use. They characterized this shift as moving away from the role of "keeper of the knowledge" to one of "learner" within a "community of learners" in the classroom. Teachers characterized their relationship with students as becoming more "reciprocal" since the introduction of the laptops.

> I think we've all been pretty confident about giving up [control] as far as being the "teacher" within the classroom. . . . Kids are teaching us and then I'm showing other kids or I'm showing staff members. You know it's exciting, it's reciprocal. (teacher, non-pilot school, November 2003)

> I think the biggest thing is teachers moving from being the keeper of knowledge to the facilitator of what's happening in the classroom. (teacher leader, pilot school, December 2002)

> I see the teachers becoming more facilitators and directors instead of always having to have the information, the answers. More and more the kids are becoming the owners and the directors of their learning. (teacher leader, pilot school, December 2002)

> It made much more of a community of learners, it was cozy, everybody working together, and the kids weren't necessarily viewing the teachers as the authorities, they were the facilitators. (teacher, pilot school, December 2002)

> I see people are more comfortable with trying things that they didn't necessarily understand, taking on things with the kids, learning sort of side-by-side with them, and that was sort of a process we had to get used to. (teacher leader, non-pilot school, October 2003)

Although some teachers may have viewed themselves as "learners" with students prior to the laptop program, the rapid introduction of laptops in the classroom and need to figure many things out "on the fly" pushed teachers to involve students in solving problems and answering questions related to the laptops to a greater extent than in the past. In the process of doing so, teachers gained new respect for students' knowledge and skills, and revised their views about what roles teachers and students should play in the learning process. All teachers, regardless of their technology expertise, had to acknowledge they were learners in the area of technology, and that students could be valuable "teachers" as well as learners.

Broader Changes in Classroom Practice

Principals and teachers also reported broader shifts in pedagogy and practice as a result of laptop use in the classroom. Among the changes they noted were: movement away from direct instruction to the role of "facilitator" or "coach"; increased use of an inquiry approach as opposed to memorization and practice; increased use of interdisciplinary or integrated approaches; increased use of cooperative or collaborative structures for learning; and increased use of differentiated or individualized learning tasks. Some typical comments included the following:

> I guess my mind shift has moved from being someone that thought memorization, knowing the facts, those sorts of things, to knowing where to get those things. It's been a real shift of thinking for myself and my colleagues. (teacher, pilot school, December 2002)

> It's forced me in many instances to be more of a guide than your traditional teacher who dishes out the knowledge. We are all kind of learning together as we use the laptops. (teacher, non-pilot school, February 2003)

> A lot of time with the laptops, you give them ideas to go find things, and then they take off. They go, and now you're facilitating. It's a different way of teaching. It's new to me. (teacher, pilot school, December 2002)

> Their [teachers] role is becoming more of a coach facilitator, director, kind of thing, and the students are just able to do so much more independently. (principal, non-pilot school, November 2003)

> We used to go, "Here's the math book, let me start on page one." And I knew every day what I was going to do. I was going to do the next page. But now I don't always know what I am going to do, because it depends on the kids... Because of our [district] leadership, we are moving them [teachers] towards total integration. . . . I think the laptops are making it easier for them to get there, because they can see the information is there. (teacher, pilot school, December 2002)

> The textbook is our map, more or less, and then the things that come up that interest the kids, that's where we go, not what I want to learn or teach them. (teacher, pilot school, December 2002)

> We read a story about hummingbirds. . . . My students said, "Can we do a little research piece on hummingbirds? It's interesting." And I said, "Of-course." So they initiated the work, they made a slide show around hummingbirds, and from that they learned [teacher lists several facts about hummingbirds]. (teacher, pilot school, December 2002)

Formal and informal observation of classroom activity in the study schools. confirmed the use of cooperative learning strategies in the classroom, teachers' role as facilitators, and the use of both interdisciplinary and inquiry approaches to learning. Observations also noted some use of individualized and differentiated student activity with laptops. Teachers sometimes structured activities so that students could investigate topics of interest to them individually, or to choose to research topics in more depth than required. Teachers also structured assignments in a way that allowed students at different ability levels to engage in the activity at different levels of depth. One teacher explained:

> [Y]ou can vary the reading level that you give to different children, about having to look up something, so you can encourage them to research it at a higher level, not only as a presentation tool, but as a research tool, it [laptop] allows for differentiation within the curriculum. (teacher, non-pilot school, October 2002)

Another teacher said: "They can take their learning to the next level, and I've seen that especially in the area of math, because they have resources available that allow them to go beyond what the expectations are" (teacher, pilot school, May 2003). Due to the small number of observations, the primary evidence for individualization and differentiation comes from teacher interviews.

Survey data indicate that teachers use small groups along with other instructional strategies. In the fall 2003 student survey, 29% of the responding students (n = 12,380) said they work in small groups a few times a week or more often. In the fall 2003 teacher survey, most of the responding teachers (83%, n = 347) said they have students work in small groups 30% of the time or less often during an "average week." Most teachers, 73%, said they instruct the whole class between 20 and 50% of the time. While teachers said they had begun to shift more toward the use of collaborative learning strategies, there was room for additional movement in this direction.

Perceived Benefits of Role Shifts and Instructional Changes

Benefits for Students

Respect. Interviewees described several important benefits for students resulting from students' increased opportunities to share and teach others what they know about computers. One of the most significant benefits for students was the opportunity to gain respect from others, both students and adults, within the school community. In numerous comments, teachers acknowledged students' greater skill and ease with computers. By acknowledging students' skills and accepting help from students, teachers were demonstrating an attitude of respect toward students. One teacher said, "I don't have to be the expert any more. . . the students and I are at a level together" (teacher, pilot school, December 2002). Another teacher said:

> [T]hey [students] teach each other so much. And they share information on how to do things. . . so it changes the way class is done, because I have no fear of jumping into programs or new things, because I feel like I'm not the only teacher in the room now, because the kids do a lot. (teacher, non-pilot school, March 2003)

An eighth-grade student said:

> I think a lot of people have learned to respect each other with the computers, with people always needing to know what to do . . . I think that the teachers are learning more about the students now that we know how to use our laptops and the teachers are seeing how well we can communicate with each other. (student, pilot school, May 2003)

Other comments that described students' feelings included:

> They [students] feel really good when they can come up and do something and have input. They seem to be very proud. (teacher, pilot school, May 2003)

> They feel like they're on the same level with you. They're on the same plane in some things and they're always talking about this website and that website. (teacher, pilot school, May 2003)

Confidence, self-esteem. Similarly, being recognized and valued as a source of knowledge or expertise were viewed as contributing positively to students' personal confidence or self-esteem. Many teachers used the word "empowering" to describe the impact on students.

> I think they feel empowered because they can show me things on the computer that I don't understand. . . . That reverses the role of student and teacher, which is fun for them and for me too. (teacher, pilot school, December 2002)

> I think that the kids that aren't typically successful in classrooms feel a little bit empowered. They know stuff about it [laptop] . . . they've figured out that I'm fine with saying "I don't know." (teacher, pilot school, February 2003)
>
> It's really neat when the students think they can help you. It empowers them to take risks and think ahead. (teacher, pilot school, May 2003)

A parent talked about how the experience of teaching the teacher had impacted her son:

> I think his confidence level has gone up, because he's just picked it up so easily. His teacher's . . . well . . . her expressing that he knows more and, "Could you show me how to do this?" and things like that. (parent, pilot school, February 2003)

In particular, teachers noted the positive benefits for low-performing or special-needs students to gain confidence or self-esteem because of their increased opportunities to be helpful to others in the classroom and to be viewed as knowledgeable by peers and teachers. Some teachers commented:

> I think it's [the laptop] just, emotionally, it makes them feel powerful. It makes them feel equal. (teacher, pilot school, April 2003)
>
> I think that's maybe the big point, because it's like an equalizer. The special ed student has just as much power with that laptop as an accelerated/gifted student would have. I think the kids realize that and appreciate it and [it] gives them more stature. (teacher, non-pilot school, February 2003)
>
> I think it's helped them get self-esteem and the fact that they have been able to get help and they have been able to have successes with the i-Book. (teacher, pilot school, December 2002)

Increased interaction with adults. Students helping teachers and other adults in the school with technology questions or tasks gave students more opportunities to interact with adults in the schools. This interaction typically occurred spontaneously and informally during classroom lessons, but also occurred through formal structures.

In general, students and teachers reported in the interviews and surveys that they were interacting and communicating with each other more frequently since the introduction of laptops, and particularly in schools where they had access to e-mail. In the fall 2002 teacher survey, over 60% of the teachers reported increased teacher interaction with traditional, at-risk, and special education students, and just under 60% of the teachers (n = 625) reported this impact for high achieving students, since the introduction of the laptops (Silvernail & Lane, 2004). In the fall 2003 student survey, 47% of the responding students (n = 12,309) agreed (somewhat agreed,

agreed, or strongly agreed) with the statement: "Now that I have my laptop, I interact with my teachers more." Students e-mailed their work to teachers or placed their work in the teacher's "folder" on the fileserver, and teachers gave feedback to students via e-mail. Both teachers and students viewed this increased interaction as a positive change.

> It's [laptops] allowed me to interact with them [students] more because they're doing the learning, they're doing the research, and I get to be a part of that in and amongst them, as opposed to standing up in front and giving it all to them. I actually feel like I teach more in the way that I want to teach. I'm guiding and I'm not handing out information (teacher, pilot school, November 2002)

> I've seen tremendous input from teachers giving feedback to kids immediately on their reading or writing papers that they send to them. (teacher and technical coordinator, pilot school, December 2002)

> I like how you can e-mail the teachers so you can find out if you missed a day of school, and be like "Did I miss anything yesterday?" "Oh, you have to do this worksheet and this page." (student, non-pilot school, June 2003)

> We e-mail our reports and stuff to our teacher and she'll comment on them and they'll revise them and send them to the teacher. (student, pilot school, April 2003)

> We've been using it [laptop] a lot for research and typing up stories and keeping notes and making presentations. Also, contacting teachers through e-mail with questions, and using the message boards and e-mail to ask about math problems. . . helping to do homework and stuff. (student, pilot school, May 2003)

Increased collaboration with peers. Another important benefit for students that teachers described was the increased interaction and collaboration among students in general.

> They [students] help with their peers better than I can. They are communicating with one another more frequently than they did before. (teacher, pilot school, June 2003)

> [T]here have been a lot of situations where you see kids that normally wouldn't be as confident or wouldn't be as helpful to other students, but when it comes to using the laptops, if they're a student that's kind of computer savvy, they are more likely to help other students. . . I definitely think it's helped communication amongst the students. (teacher, pilot school, May 2003)

> I see a lot of collaboration between students teaching students. People who don't normally speak well in front of their own classmates getting up and shining and really being articulate with people they don't know, and I think that's an amazing social piece I didn't even dream would take place with the project. (teacher and technical coordinator, pilot school, December 2002)

> And when they [students] help each other, they're really helping each other. They're very kind to each other. They have a lot of patience with one another. (teacher, pilot school, December 2002)

Teachers also described how students helping each other with the laptops helped to "build bridges" across different groups of students. Administrators and teachers said the laptops had prompted increased communication and collaboration between high-achieving and low-achieving students, between regular education and special education students, between student-designated social groups, between boys and girls, and across grade levels.

> [E]ven the ones that aren't friends, they do interact and help one another out. . . . So I think that it does build some bridges too. (teacher, non-pilot school, March 2003)

> One of the big things that I see is the collaboration . . . when they find something or how to do something really neat they share it with each other and they help each other out . . . just the cooperation among the different kids. And kids that normally wouldn't hang out or talk to certain other kids. They kind of cross those boundaries. (teacher, pilot school, November 2002)

> It helps them [special needs students] build relationships also, that they wouldn't perhaps be able to build . . . their self-esteem is raised because of it, and it's really made an impact. (special education teacher, pilot school, March 2003)

> There's a lot of cooperative work, where kids who are struggling and have some deficits are actually able to participate very well, just like all the other kids. (principal, non-pilot school, November 2003)

> It fosters a lot more cooperation between the kids . . . it has created a lot more opportunities for interactions between peers in terms of sixth, eighth, and seventh graders interacting in a more positive fashion. (multi-age classroom teacher, pilot school, December 2002)

> [I]f one kid's laptop isn't working, another child will always say, "Hey come on over and see what I've got," and it's not a boy/girl thing so much. I think that gender element in middle school isn't present there. (teacher, pilot school, December 2002)

In the fall 2002 teacher survey, over 70% of the teachers reported improved interaction between students for traditional, at-risk, and special education students, and just under 70% of the teachers (n = 625) reported this impact for high-achieving students, as a result of the laptops. Increased interaction across different groups of students translated into increased respect between these groups, and increased self-esteem for the students who had formerly been ignored or marginalized within the classroom or school.

Increased interaction and collaboration among students contributed to positive improvements in the classroom learning environment, by strengthening students' respect for each other and by encouraging a sense of shared learning. One student said:

> When people research different topics . . . [or] when people do the same topic, you'll have some of the same information, but then someone will find this wicked interesting fact that no one else knows, and you'll be like, "Wow, I didn't know that!" . . . it's really interesting to find out what other people learned. (student, pilot school, May 2003)

Increased student impact on learning tasks. By allowing students to share web-based information sites with the classroom, students were able to more directly impact the resources available for student learning. Instead of teachers controlling or specifying a limited set of information resources, students in many classrooms had opportunities to find their own sources of information through Internet searches they conducted in school or at home. Teachers allowed students to share useful websites with others in the class. Out of the 22 classroom observation records, 17 of the observed lessons involved students doing research via the Internet, and in 12 of these lessons the teacher allowed students to freely search for websites and information without restricting which websites could be used. In 10 lessons, students were observed sharing the results of their research on the Internet with their classmates and teacher.

Further, where teachers used inquiry-based instructional approaches and allowed students to pose their own questions on topics of interest to them, students had opportunities to directly impact the content and focus of classroom lessons and to share knowledge on diverse topics with others in the classroom. All but 2 of the 22 classroom observations involved students engaged in inquiry. Two math lessons were fairly traditional and involved student practice of arithmetic skills. Students practiced math skills with laptops on a web-based program in one lesson. Students had the opportunity to choose their topic or research questions in 7 of the 22 observed lessons, and students chose the form of their product in 7 of the 22 observed lessons (see Table 5).

> This [having laptops] actually gives the kids more of a responsibility to be active participants in their own learning. (teacher, non-pilot school, May 2003)

> I think it's given them tons of control over their own learning and decision making, which is exactly what middle school kids need to learn to do. (teacher, pilot school, May 2003)

> I think that it will put it [learning] more into the students' hands, and so there is less lecturing. It even individualizes it a little bit more. (teacher, non-pilot school, March 2003)

Increased opportunities for individualized learning. Teachers' shift to the role of facilitator and increased use of an inquiry approach to learning also allowed for greater differentiation within the curriculum or within classroom assignments/activities. Teachers described how the use of one-to-one computing in the classroom allowed them to individualize learning tasks to meet the different learning needs of students. While students engaged in the same activity, individual students had the freedom to choose topics or questions to investigate (typically researching through Internet searches), and to choose a format and level of depth for researching and reporting their findings. Six of the 22 observed lessons included individualization of student work. Students who wanted to investigate a topic in more depth had that freedom, and students who found tasks challenging could be paired with other students to work collaboratively. Low-performing and special-needs students could still produce a neatly typed document and an attractive presentation like any other student in the classroom.

In the fall 2003 teacher survey, over 70% of the teachers (n = 359) agreed (somewhat agreed, agreed, or strongly agreed) with the statement: "I am better able to individualize my curriculum to fit students' needs as a result of having the laptops." Approximately 85% of the teachers (n = 357) agreed with the statement: "I am able to explore topics in greater depth with my students when we use the laptops" (Silvernail & Lane, 2004).

Designing tasks to meet students' different learning needs was viewed as having positive benefits for student learning, for students' self-esteem, and for students' motivation to learn and to actively participate in classroom activities. The most salient view about the impact of the laptops on students, from all interview and survey respondents, was the perception that the laptops had increased students' motivation and engagement in learning and doing their schoolwork. In particular, teachers emphasized the positive impacts on the self-esteem and motivation of special-needs and low-performing students. In the fall 2002 teacher survey, over 80% of the responding teachers (n = 621) reported an improvement in student motivation and in student engagement for both at-risk and special education students, since the introduction of the laptops a year earlier (MEPRI, 2003; Silvernail & Lane, 2004). In the fall 2003 student survey, 73% of the responding students (n = 12,248) agreed (somewhat agreed, agreed, or strongly agreed) with the statement: "I am more interested in school when we use the laptop."

Benefits for Teachers

Teachers described three broad ways in which they benefited from the role shifts of teachers and students in the classroom.

Teachers' technology knowledge and skill. Teachers' directly increased their knowledge and skill in using computer software, hardware, the Internet, and e-mail whenever students "taught" teachers how to do tasks with their laptops. Although this knowledge and skill was gained informally, teachers could immediately put it to good use within the lesson or activity they were conducting in the classroom. Teachers commented repeatedly in the interviews about students knowing more about how to use computers, students being the best resource for computer-related questions, and described the types of tasks for which they typically seek help from students.

Help with technology questions, problems. The MLTI program included a technology team in each school, consisting of the principal, a technology coordinator, and a teacher leader. In some smaller schools, individuals served in two of these roles at the same time. Typically, the person serving as general technology support for the school was given the additional responsibility for laptops as the technology coordinator. Teacher leaders were regular classroom teachers, who may have had some of their teaching duties reduced, but generally did not. Teacher leaders helped other teachers in their schools by providing information, mentoring, coaching, and leading teacher professional development sessions. In the pilot schools, one teacher was designated as a RIM (Regional Integration Mentor), and was responsible for providing support and professional development to teachers in the pilot school as well as in other middle schools in the RIM's superintendent region. Therefore, pilot schools had more MLTI leaders to assist with laptop related glitches, tasks, and teacher training. The state educational agency provided on-going professional development to teachers, RIMS, and school laptop team members throughout the first two years of the program, and continues to offer training. Funding for the program included stipends for both RIMs and teacher leaders. In the second year of the laptop program, some schools budgeted for a stipend for an additional teacher leader for the eighth grade.

By training students to assist the adult team members on "i-Teams," schools enlarged their capacity to provide tech support to teachers and students. When formal tech help was not readily available, teachers could also turn to students informally for help with some tasks. The

fact that many students were skillful with computers, and that teachers were willing to accept help from students, meant that teachers had a convenient source of immediate help available in their classrooms, and did not have to wait until a staff member was available to answer questions.

Classroom management . Enlisting students to help resolve other students' technology problems or questions helped teachers with classroom management. As teachers reported moving away from direct instruction to more collaborative or individualized student work, they found it challenging to be everywhere in the classroom to answer students' questions. Making use of students as "experts" in the classroom increased the number of people available to help students.

> The kids have gotten really good about troubleshooting and that's helped us too, because when I'm a teacher and I have twenty students and everybody needs help, if I have other students that can help troubleshoot it's great, because they help each other out. (teacher, pilot school, May 2003)

> I don't have the time to get around to every student that is having trouble. The person next to them will just say, "Oh, I can help them." And they will go over and help the other student, which has been wonderful. (teacher, pilot school, December 2002)

Benefits for Classrooms and School Communities

Teacher and student role shifts benefited both teachers and students, as described above. Yet the role shifts also benefited the classroom and larger school community in a variety of ways. As teachers became more aware of students' technology skills and involved students to a greater extent in helping and teaching others, students gained more respect from teachers and other staff members in the school. Greater respect for students' technology skills could translate to greater respect generally between teachers and students in the school, and more positive forms of interaction and collaboration.

Students who traditionally held more marginal positions, socially or academically in the classroom or school, gained greater respect from their peers and a sense of equity. Teachers saw evidence that the laptops helped students to "build bridges" across the barriers of academic ability, disability, gender, social grouping, and grade level. Hopefully, attitudes of respect, equity, and increased interaction across different groups of students have carried over into wider school activities and the school community.

In recasting their role as "learners" with students, teachers encouraged the development of "communities of learning" in the classroom, and a shared sense of excitement in the learning process. By showing students that it is natural not to know all things, to be curious, and to learn by exploring and sharing, teachers were modeling positive attitudes toward learning and a practical approach to the learning process.

As teachers used the laptops as a vehicle for making broader changes in instructional practice, such as collaborative, interdisciplinary, and inquiry approaches to learning, they modeled new ways of thinking about teaching and learning for their peers. Although teaching remains highly idiosyncratic, the kinds of collaboration that teachers engaged in to incorporate technology into their practice could easily lead to school-wide changes in classroom practice.

Together, the effects of these shifts in classroom roles and classroom practice serve to foster a positive, and collaborative learning environment for teachers and students in classrooms and in the wider school community.

Discussion

This paper describes changes in teacher and student roles in the classroom, the benefits associated with these changes, and broader instructional shifts in pedagogy and instructional approach resulting from the use of one-to-one wireless computing in Maine's seventh and eighth-grade classrooms. When one compares the program's early results with the initial goals, it is clear that the laptop program has, in fact, stimulated many of the changes in teaching and learning that were envisioned.

For example, the vision for transforming classroom practice included the following goals: ". . . engaging students in self-directed, personalized learning projects that can tailor the curriculum to student interests and engagement, and allow teachers to facilitate active student learning rather than merely the rote transfer of information"; a "constructivist approach [that] supports and demands students to use higher-order thinking skills to make sense of their experience," and classroom environments where teachers and students "are learning together" (Task Force on the Maine Learning Technology Endowment, 2001). Further, the impacts of the laptop program support Maine's learning goals for students which, broadly, include: positive attitudes toward learning; communication skills; creativity; logical thinking skills; problem-solving skills; information finding and evaluating skills; ability to make connections across

disciplines; and understanding the power of technology as a tool (Maine Department of Education, 1997, 1990).

More work needs to be done to compare the early results of Maine's laptop program with the results of other laptop programs around the country. The ERIC database includes many citations of laptop programs around the U.S. and abroad, at all levels of education from elementary through college levels. The extent and quality of research and evaluation of these programs varies a great deal. Still, a cursory examination indicates that studies are describing many positive impacts of laptop use on teaching and learning.

Studies using a case study, ethnographic, or evaluation methodology reported the following findings: increased student collaboration and use of project-based learning (Windschitl and Sahl, 2002; Yang 2002); a shift to inquiry or problem-based learning (Yang, 2002); shift to student-centered learning (Newhouse & Rennie, 2001); a shift in teachers' role from lecturer to facilitator (Yang, 2002); and changes in teachers' conceptualizations of pedagogy (Parks, Huot, Hamers, & Lemmonier, 2003). These findings are largely consistent with the findings of the current study. The author found no publications that focused on students' emerging role as technology "teacher" in classrooms or schools. More research is needed to see if the changes in teacher and student roles and in classroom practice are found across all grade levels, subject areas, and types of schools. Further, more research is needed to understand what factors support these positive changes and for which teachers and students.

The findings presented in this study reflect the initial impacts of a laptop program within the early stages of the program's implementation. The evaluation findings were overwhelmingly positive throughout the first year and a half of the program. Further study of this program may reveal changes in the current perceptions and practices. One area to investigate is the broader impact of laptops on parents, families, and communities. Two of the non-pilot schools in the current study (very small, rural schools) made initiatives to increase parents' technology skills by buying additional laptops or opening up their computer lab for parents' use and offering parents computer education. This type of effort could have far reaching benefits for families by increasing parents' literacy and computer skills, improving parents' employment options and resulting income, and improving parents' communication with their children and involvement in their children's education.

The chief limitations of the evaluation and the current study are: the small number of classroom observations in some of the schools, and the lack of data on teacher and student roles and on classroom practices in the study schools prior to the laptop program.

The most intriguing point about the early results of Maine's laptop program is that the changes in classroom roles, teachers' pedagogical views, and practice were both rapid and dramatic. Many educational reform efforts have sought to encourage the kinds of changes described in this paper through educational standards, testing, teacher professional development, and curriculum change. Yet, these efforts typically result in small and variable impacts at the classroom level, and appear to require a good deal of time before real change is perceptible (e.g., Firestone, Schorr, & Monfils, 2004; Firestone, Mayrowetz, & Fairman, 1998; Spillane, Thompson, Lubienski, Jita, & Reimann, 1995).

By contrast, the laptop program appears to have resulted in rapid and significant shifts in the way teachers and students interact and teachers structure student learning. The changes in teacher and student roles have produced a more equal or reciprocal relationship between teachers and students, more communication, and more respect between teachers and students. The changes in classroom practice have increased the level of student engagement in learning, increased use of an inquiry approach to learning, increased collaborative learning among students, and increased interactions and respect across different groups of students. Further, there is evidence that the laptops facilitate individualization and differentiation within the curriculum, to allow students to work at their own level, yet feel equal to their peers. By increasing students' motivation to learn, and giving students more opportunities to control different aspects of their school work (e.g., choice of topics or questions to investigate, choice over depth of inquiry, choice of information resources to use, choice over products to demonstrate learning, and choice over independent or collaborative work), students are able to take more "ownership" of their learning and school work.

Necessity forced many teachers to learn technology skills from students in the early days of implementation, but this interaction had the more permanent effect of creating more collaborative, reciprocal roles in the classroom. Teachers no longer feel the burden to "know everything," and teachers and students report that they are learning together. This image of teaching contrasts sharply with traditional practice, where teachers maintain control over knowledge and students' access to information resources in the classroom.

Conclusion

The laptop program in Maine not only increased teachers' and students' knowledge and skills with computers—it also prompted positive change in the interactions between teachers and students and among students, and in the mode of student learning. These shifts benefited both teachers and students socially and educationally. The results of this study hold implications for policy and practice. At the level of state and district policy, putting technology into classrooms, and directly into the hands of students, appears to be an effective strategy for encouraging broader educational reforms in a short period of time. Although an expensive strategy for educational reform, the positive impacts appear to be significant and many. The results also suggest that teachers can give up some control over the content and process of learning without fear. Where teachers model positive attitudes and effort in learning, students can be inspired to engage in similar work. Learning together creates a more reciprocal relationship, where teachers and students learn from each other and increase their respect for other learners.

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APPENDIX

Table 1. School Sample in Evaluation Study

Type of School	Grade Configuration	*N*
Middle School	6-8	11
Elementary School	K-8	9
Elementary/Secondary School	K-12	2
Middle/Secondary School	6-12	1
School Sample		23

Table 2. Interviews Coded with *NUD*IST* Software

	Administrator Interviews	Teacher Interviews	Student Interviews	Parent Interviews	Total
Pilot School (*n* = 9)	28	89	60	9	186
Non-Pilot Schools (*n* = 14)	33	55	26	1	115
Total	61	144	86	10	301

Note. Teacher interviews included regular classroom teachers, unified arts teachers, special education teachers, and educational technicians. Administrative interviews included superintendents, principals, and technology support staff. Some teacher and student interviews included two or three interviewees.

Table 3. Coded Interviews by Superintendent Region and School Type (Pilot or Non-Pilot)

Superintendent Region in Maine	Pilot School	Non-Pilot School	Total
Region 1 (Aroostook)	28	17	45
Region 2 (Penquis)	22	21	43
Region 3 (Washington)	9	0	9
Region 4 (Hancock)	14	0	14
Region 5 (Midcoast)	9	26	35
Region 6 (Western Maine)	26	19	45
Region 7 (Cumberland)	23	2	25
Region 8 (Kennebec)	29	30	59
Region 9 (York)	26	0	26
Total			301

Table 4. Coded Observations by Region and School Type (Pilot or Non-Pilot)

	Observations		
Region	Pilot School	Non-Pilot School	Total
Northern Maine	0	3	3
Central Maine	8	2	10
Western Maine	1	0	1
Coastal Maine	1	7*	8
Total (7 schools)			22

*Observations were conducted in two different schools.

Table 5. Coding of Classroom Observations by Subject Content Area

	Observations						
Coding Categories	English Lang. Arts (*n* = 3)	Social Studies (*n* = 5)	Science (*n* = 6)	Math (*n* = 5)	Computer Education (*n* = 2)	Portfolio Assessment (*n* = 1)	Total (*n* = 22)
Teacher facilitator	2	5	5	4	0	1	17
Teacher direct instruction	1	0	1	1	2	0	5
Students help students informally	3	3	2	3	2	1	14
Students work in pairs or groups	1	3	2	0	2	0	8
Research on Internet	2	5	6	2	2	0	17
Open web search allowed	2	3	3	2	2	0	12
Restricted web search	0	2	3	0	0	0	5
Students share information from web search	2	1	2	0	0	0	5
Individualization (student choice of depth/length of work)	2	1	2	1	0	1	7
Student choice over topic/ research question	2	2	3	0	0	0	7
Student choice over form of product	1	2	2	1	0	1	7

Note: Direct instruction includes: lecture, demonstration, recitation. Math lessons included one seventh grade algebra lesson, three lessons on personal budgeting, and one lesson on percentage in a special education resource room.