When Each One Has One:

Technology as a Change Agent in the Classroom[1]

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[1] Data for this paper is based on a three-year study conducted by the authors and reported in the annual evaluation reports accessible at http://www.nteq.com/?p=research. Data from the third year were reported in Lowther, D. L., Ross, S. M., & Morrison, G. R. (2003). The Laptop Classroom: The Effect on Instruction and Achievement. *Educational Technology, Research, and Development, 51*, 23-44.

Technology has long been viewed as a means to deliver instruction since the lantern slide projector was introduced into the classroom in the late 1800's. This conception of technology has guided its use through the last century with the introduction the overhead projector, 16mm film projector, television, and more recently microcomputers and PDAs in the K-12 classroom. The U.S. Congress added support to this approach with the passage of the National Defense Education Act as a reaction to Sputnik in 1957 that resulted in the placement of overhead projectors in many K-12 classrooms to improve instruction. While Clark's (1983) research suggests that technology as a mere delivery device does not enhance learning (separate from the associated instructional strategies), school districts continue to purchase additional technology and new technologies to improve student achievement with little if any documented return on the investment. Recent data indicate that 61% of the homes in the United States and 93% of the instructional classrooms have access to computers (*Statistical Abstract of the United States*, 2007). Yet, recent research indicates that fourth and eight graders are more likely to use computers to play games while eleventh graders are more likely to write papers (Day, Janus, & Davis, 2005).

While many researchers agree with Clark and have abandoned the media comparison research agenda to identify learning gains attributable to technology, a question still remains as to what effects technology might have on instruction and the classroom environment. In this paper we will examine how a technological innovation affected changes in the instruction and the classroom environment that subsequently resulted in improved student achievement and performance during a three-year study.

Background

A Midwestern, suburban school district made a decision during the 1998-1999 school year to implement laptop classrooms in the fifth and sixth grades. During the initial year of implementation, parents leased a laptop from a school approved vendor. Families who wanted to participate in the project, but could not afford a laptop lease, were assisted by the district's foundation. Once approximately 25 students in a grade level in a school made a commitment to lease a laptop, a laptop classroom was created. Participation in the program was voluntary. A student in the laptop project attended classes in the four content areas (i.e., math, science, language arts, and social studies) exclusively with other laptop students. The district developed each school's infrastructure to include wireless Internet access and networked printers.

The research team became involved in the project during the planning year and helped the school plan the implementation and evaluation of the project. Specifically, the District decided to implement the NTeQ model (Morrison & Lowther, 2005) as the approach for integrating the laptops. For this paper, we are defining the technology innovation as the introduction of laptop computers to the class and the teacher training in how to integrate the technology into the classroom. The following is a brief description of the activities related to the implementation of the project.

Year 1

Training for the project started with the distribution of the leased laptops in early July. Teachers participating in the project received a laptop from the district that was identical to those used by the students. Parents were encouraged to attend evening

training sessions on the operating system and Microsoft Office that were taught by the laptop teachers.

The laptop teachers attended ten full days of training focused on the NTeQ model during early July. The NTeQ (iNtegrating Technology for inQuiry) model uses an inquiry-based learning approach to integrate computer technology as a tool rather than as a delivery system. A ten-step model is used to develop the inquiry-based lesson (see Figure 1). During the training sessions, teachers learned how to develop integrated lessons using the model. Each teacher was expected to develop at least two integrated units of instruction they could use during the school. The teachers were also encouraged to work as a team and develop a unit of instruction that would integrate two or more of the core content areas that the teachers could team teach.

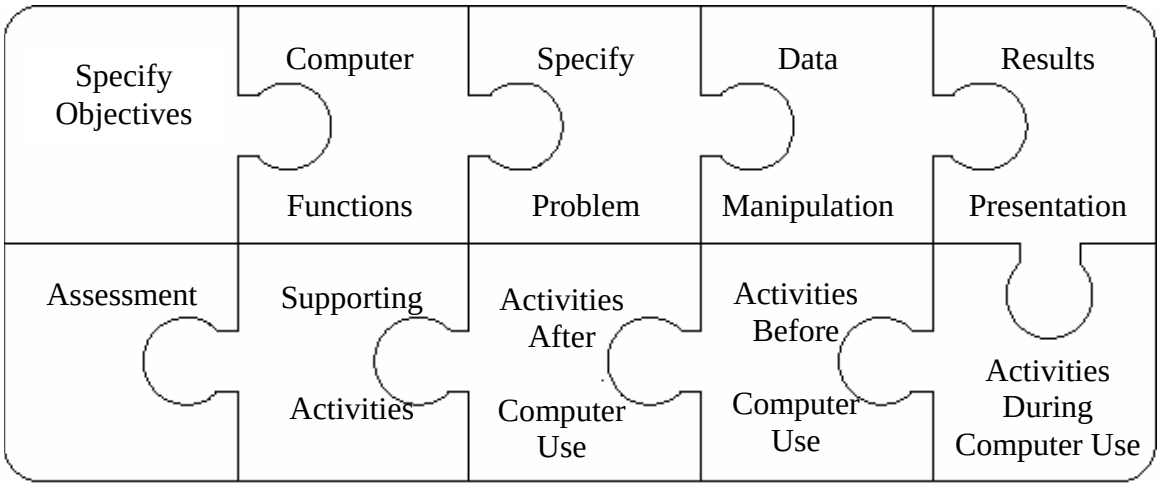

Figure 1: NTeQ Model

During the school year, the lead author of this paper conducted six, one-hour support sessions for the laptop teachers. These sessions primarily focused on question and answer sessions with the teachers working together to solve implementation

problems. Additional information sessions were held periodically for parents of students in the laptop classes.

Year 2

During the spring of the first year, a second NTeQ training program was held for teachers wishing to participate in some aspect of the program in the second year. This training was offered twice a week after school and was equivalent to a three-hour graduate course. Content for this course was expanded to develop additional units of instruction and approaches to utilizing the Internet into the classroom. A similar workshop was conducted during the summer with the first year's laptop teachers serving as coaches.

In the second year, the previous year's laptop students were promoted to the sixth and seventh grade laptop classrooms. New students entered the project at the fifth grade and additional sixth and seventh grade laptop classrooms were created when 25 students in a school opted to participate.

Based on the success of the first year's implementation, a new classroom configuration was tested. Teachers who had attended an NTeQ training session could opt for 4-6 desktop computers to be placed in their classroom to allow them to implement the NTeQ model. These computers had Internet access and access to a networked printer placed in the room. These computer-enhanced (CE) classrooms provided a comparison for the laptop classrooms for the Year 2 evaluation.

During the school year, the lead author met approximately four times with the laptop and CE classroom teachers to address issues and solve problems. Similarly, occasional meetings were held with parents to answer questions about the project.

Year 3

In the third year, the laptop students once again took their computers with them to the next grade level, thus expanding the program to grades five through eight The district also provided laptop carts for extended times to non-laptop teachers who participated in the NTeQ training . The laptop carts afforded the additional advantage over the computer-enhanced classroom by providing each student with a computer rather than sharing one during the class time. Experienced laptop teachers provided teacher training for new teachers in the third year was conducted during the summer by experienced laptop teachers. Support during the year was provided by the more experienced teachers. One of the lead teachers from Year 1, was promoted to a position in the central administrative office to provide teacher training and support throughout the year.

Research Design

The research in the first and second years was guided by three research questions. First, is teaching different in a laptop classroom? That is, do teachers use different methods in the laptop classrooms as compared to traditional, computer enhanced (CE), or laptop cart classrooms? Second, do students achieve differently in a laptop classroom? Are there changes in the classroom environment that will influence student achievement as the result of the introduction of this technology innovation? Third, do students behave differently in a laptop classroom? In a classroom where each student has 24/7 access to a laptop computer and wireless Internet access in the school, is there a change in student behavior due to the technology innovation?

The focus of the research in the third year was on just the fifth grade students and comparing the laptop classrooms to classrooms with extended access to laptop carts. Six questions guided this research.

- What differences emerge in teaching strategies used during a computer-supported lesson in laptop versus cart classrooms?
- Do laptop students differ from cart students in their writing skills?
- Do laptop students differ from cart students in their approach to problem solving?
- Do laptop students differ from cart students in their mathematics, science, and social studies achievement at the 5th grade level?
- How do students perceive the use and access of laptop computers?
- What do teachers perceive as the benefits and problems of integrating technology in laptop vs. cart classrooms?

Data Collection

The data set for the evaluation included classroom observations, student writing scores, standardized test scores, student surveys and focus groups, teacher surveys and interviews, and parent surveys and interviews. Two separate observation measures were used to collect data: The *School Observation Measure* (*SOM©*), and the *Survey of Computer Use* (*SCU*). *SOM©* were based on 60 continuous minutes of observation, divided into 4, 15-minute segments. These 4 observation periods were then summarized on one *SOM©* Data Summary form. *SCU* was completed as part of the 60-minute observation sessions, only if students used technology during that time.

The District's *Writing Scoring Guide* was used to assess prompted writing samples from laptop and control students. At the end of each school year, students wrote a letter of introduction to next year's teacher. These letters were collected and scored with the rubric. Experienced reviewers used the district's four point rubric (ranging from 1 to 4, with 4 being the highest rating possible) to conduct a blind assessment of the writing samples for Ideas and Content, Organization and Form, Style, and Conventions, yielding four scores per student.

The questions for the student, teacher, and parent surveys, interviews, and focus groups focused on three areas: the impact of laptop computers on increasing personal skills (research, computer, and learning), the impact of laptops on what happens in the classroom, and the benefits, difficulties, and suggested improvements of the laptop program.

In the second and third year, a researcher designed problem-solving instrument was developed with input from participating teachers. This instrument presented students with a problem at a local park where soda pop cans were not being recycled (there was a $.10 refundable deposit on every can). The students explained how they would approach solving the problem. The solutions were evaluated with a problem-solving rubric consisting of "Understands problem," "Identifies what is known about the problem," "Identifies what needs to be known to solve the problem," "Determines how the data need to be manipulated to solve the problem," "Describes use of technology," "Describes how to present findings," and "Collaborative learning."

In the third year, student achievement was assessed with scores from the district administered test to measure the following Michigan Curriculum Standards and

Benchmarks: mathematics (1-4), science, and social studies. The students' fourth grade (pre-laptop) MEAP mathematics total raw scores from 2001-2002 were used as a covariate to control for initial differences among students when making program comparisons. In addition, the observations included the *Rubric for Student-Centered Activities (RSCA©)*, which assessed the meaningfulness with which strategies such as cooperative learning and project-based learning were practiced, and whether, in the process, technology was employed by students as "producers of knowledge."

Technology as a Change Agent[2]

In this section we will reexamine the results of this three-year study to determine if the use of laptop computers influenced a change in the teaching methods and instructional environment. To answer this question we will examine the teaching methods, student behavior, and student achievement in laptop, computer-enhanced, laptop cart, and traditional classrooms.

This project examined three different approaches to making technology accessibility to students in the classroom. The first approach were classrooms composed of students with their own personal computers that would provide them with 24/7 access to the laptop. In the second year, the district established several computer-enhanced

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[2] The full evaluation reports for each year that report all the data can be found the NTeQ website (www.nteq.com) and provide detailed analysis and discussion of the achievement measures. Details on the results for Year 3 can also be found Lowther, D. L., Ross, S. M., & Morrison, G. R. (2003). The Laptop Classroom: The Effect on Instruction and Achievement. *Educational Technology, Research, and Development, 51,* 23-44.

classrooms that had approximately six desktop computers. In the third year, the district implemented laptop carts shared by several teachers that would provide each student in the class with a laptop for use during class time. These hardware innovations were also paired with a specific instructional approach and teacher training that focused on integrating the technology as a tool. The NTeQ model (Morrison & Lowther, in press) can be used to create problem-based, inquiry-based, and project-based instructional materials. From the teachers' perspective, the hardware (i.e., computers) and instructional approach were presented as a single innovation rather than as two separate innovations or steps to implementation. For example, in the first year the teachers received their laptop in the summer and then attended the training. In the second and third years, the teachers attended the training *before* they received their laptops or classroom computers. The following is a discussion of the results organized by research questions rather than by year. This perspective will provide insights into the role of the technology and instructional method as a change agent.

Research Question 1: Is teaching different in a laptop classroom?

The first year comparisons of teaching methods provided the most extreme contrast of the three years. In the first year, the laptop classrooms were compared to traditional classrooms that had a limited number of computers (1-4). In addition, the laptop teachers received training in how to integrate the laptops by using them as a tool to solve problems. Data from the first year suggests that teaching in a laptop classroom was different than teaching in a traditional classroom. Observations of the classrooms revealed that the laptop teachers were more likely to use student-centered approaches such as project-based learning, independent inquiry/research, sustained writing, and

cooperative learning. Similarly, the laptop teachers were more likely to use higher-level instructional feedback, use computers as a learning tool, and serve as facilitators that supported a student-centered approach. A student-centered approach to instruction has been advocated in the literature for several years (Cobb & Bowles, 1999; McCombs, 2003; Zimmerman, 1990) suggesting we might expect to see frequent examples of this strategy in all classrooms, not just a computer-intensive classroom. There are two potential explanations for these outcomes in the use of student-centered learning strategies. First, the students had ready access every day to the laptops so no additional planning (and related frustration) was required to plan a learner-centered lesson incorporating computers. Thus, the lesson could span across several days without worrying about the availability of computer access or moving the class to a computer lab. Second, the teachers were used to working in teams in the core content areas. Since all the team members had attended the training, the team and peer pressure may have provided additional support for implementing the student-centered approach. Similarly, student and parent expectations concerning the use of the laptops may have also influenced the teachers.

In Year 2, the laptop classes were compared to CE classrooms that had five to six desktop computers available to the students in each classroom. In addition, the teachers in both groups completed training on the NTeQ model and were proficient in using the Internet and Microsoft Office. In contrast to Year 1, there were fewer observations of student-centered instruction in the laptop classrooms. While the Year 2 laptop classes were certainly busy and active places compared to typical classrooms that were observed in other studies (Ross, Smith, Alberg, & Lowther, 2000), perhaps the teachers were less

influenced by a “Hawthorne-type” effect than in Year 1, and thus were less likely to demonstrate “model” lessons. There were two significant impacts in Year 2. First, the integration of subject areas was observed less frequently in the laptop classrooms. This lack of integration of subject areas suggests that teachers were working individually rather than as a team since students changed classrooms and teachers for each core subject. Second, the use of technology as a learning tool was observed more frequently in the laptop classrooms. Thus, students were still engaged in inquiry projects, but in a more teacher-centered environment than year 1. Laptop students demonstrated superior computing skills and more frequent use of word processing and use of CD-ROMs for research.

The observation data in Year 3 identified relatively few differences between the laptop classrooms and the laptop-cart classrooms. Since both groups of teachers participated in the NTeQ training and had relatively unlimited classroom access to computers, we would expect few differences. Both groups of teachers were observed serving as facilitators, using sustained writing activities, and using the computers as tools for learning. Of greater concern was the infrequent observation of cooperative learning, higher-level feedback and questioning, project-based learning, and integration of subject areas by *both* groups of teachers. These strategies, associated with best practices and improved student learning, were frequently observed in the laptop classroom in the first year of the study. Anecdotal data suggests that the teachers were modifying the NTeQ model to provide a simpler approach to integrating computer technology after the Year 1. Less emphasis was placed on project-based learning and more emphasis on using computers as a research tool for more traditional classroom activities. The training for

teachers in Year 3 of the project was conducted by the school district which provided the teachers with more freedom to present and implement a modified approach. Rogers (2003) refers to this phenomena as reinvention which is the degree to which an adopter modifies an innovation during adoption and implementation.

The results in this study are quite different from earlier studies. Earlier studies have found that computer technology was used primarily to deliver instruction (e.g., drill-and-practice and tutorials), to deliver presentations, for word processing of papers, or for searching the Internet (Becker, 2000; Cuban, Kirkpatrick, & Peck, 2001). These studies did not find a change in teaching practices of the teachers, rather word processors were used in place of pencil and paper and the Internet or CDROMs were used to obtain information as opposed to books in the library. One reason for the difference with these earlier studies may have been the lack of limited teacher training. Based on the research results, one might conclude that the training focused more on how to *utilize* the computer rather than on how to *integrate student use of the technology*. These studies reported primarily low-level uses of the technology that focused on strategies to enhance recall. In contrast, the training in the present study focused on higher level integration of the technology that emphasized the development of problem-solving and critical thinking skills. The observation data suggests that teachers implemented these higher-level integration strategies into their classroom teaching in laptop, laptop cart, and computer-enhanced classrooms.

Research Question 2: Do students behave differently in a laptop classroom?

Students in the laptop classrooms during Year 1 demonstrated a different set of behaviors than students in the traditional classrooms. The laptop classrooms were more

active, autonomous, and worked in collaborative groups, which was most likely the result of the use of project-based learning. The observations were also confirmed by the laptop teachers' interviews and surveys, which indicated the students were more independent, active, and engaged. While two-thirds of the laptop students were observed working individually in the classroom, they were frequently observed collaborating with others in sharing information, asking questions, and providing assistance. This collaboration may have been facilitated by the physical environment as the limited electrical outlets were spaced around the walls of the classrooms resulting in clusters of students in close proximity as they charged their computers, yet separated from other clusters.

The differences observed in the classrooms in the first year were not observed in the second year. Students in the CE classrooms behaved similarly to the laptop students. Laptop students tended to make more frequent and extensive use of their computers and were more likely to work independently. These observed behaviors may be due to the access provided by laptop students owning their computer. Students in the CE classroom had to either work together while sharing a computer or take turns using the limited number of desktop computers.

As in Year 2, we found no differences between the laptop and cart student behaviors in Year 3. Both groups tended to work independently and the laptop students were more likely to be engaged in independent inquiry, but not significantly so. The computer activities were considered somewhat meaningful with the laptop students engaging in more meaningful activities than the cart students.

Research Question 3: Do students achieve differently in a laptop classroom?

The data from all three years provide evidence that the students in the laptop classrooms did achieve differently than the comparison groups. In Year 1, achievement data consisted of a writing sample with a significant positive effect favoring the laptop students. The effect sizes for the four dimensions of the rubric ranged from +0.61 to +0.78 suggesting a moderately strong effect.

In Year 2 of the study, the data also revealed significant outcomes in the writing performance between the laptop and CE students. The majority of the effect sizes exceeded +.80 while the mean differences in many cases approximated or exceeded one full rubric point. Our observations did not find a difference in sustained writing activities in the two classes. However, there was a significantly greater use of word processing by the laptop students. Survey responses of laptop students and teachers indicated they felt their writing skills had improved. Another factor may have been the ratio of students to computers with the laptop classrooms having a 1:1 ratio while the CE classrooms varied with a typical ratio of 4 or 5 students per computer. During a typical 60 minute class, a student in the CE classroom might only expect 5-10 minutes of computer time compared to the 45-50 minutes afforded in the laptop classrooms. This limited time on task for the CE group may have resulted in the lower computer literacy and keyboard skills resulting in lower writing ability when compared to the laptop students.

Results of the problem-solving assessment added in Year 2 of the study also revealed that laptop students demonstrated superior problem-solving skills. The frequent engagement of laptop students in research activities as indicated by the surveys and interviews may have contributed to their performance. The combination of greater

engagement in problem-solving activities and having nearly unlimited access to the application software and Internet may have provided additional opportunity for the students to develop and refine their problem-solving skills.

Three new research questions focusing on student achievement were added in Year 3 when the new cohort of fifth-grade laptop students were compared to a new cohort of fifth-grade laptop cart students. The following paragraphs provide a discussion of each of these questions.

Do laptop students differ from cart students in their writing skills?

Results from Year 3 followed the same trend in writing performance differences as observed in the first two years. The laptop students showed significant advantages over the cart students, although the differences were directionally lower than in Year 2. These findings suggest that students with 24/7 access to laptops have advantages over those who only use laptops during class, and even a greater advantage over students in classrooms limited to six or fewer computers shared by all students.

The observations did not find any significant differences in teaching approaches between the two groups. The laptop students did use word processing software and accessed the Internet during language arts classes and when doing independent inquiry/research more frequently than the cart students. Student responses to survey items also revealed that a majority of the laptop students indicated an increase interest in learning and in overall computer skills. The combination of 24/7 computer access and the above factors may have contributed to the increased writing performance of the laptop students. Teacher training in the NTeQ model and classroom access to laptop computers with wireless Internet access were the same in both groups.

Do laptop students differ from cart students in their approach to problem solving?

Laptop students outperformed the cart students on the problem-solving assessment. However, as with the writing test, there was a Year 2 to Year 3 decrease in the effect sizes of these differences. The Effect Sizes for Year 2 ranged from +0.38 to +0.76, where as the Year 3 range was only +0.26 to +0.55. Given that all the teachers received similar training in integrating computers for inquiry and were observed using similar teaching methods, we would not expect to maintain large differences between the two groups.

Although there were no significant differences in teaching approaches between the two groups, the laptop group was more frequently engaged in independent inquiry/research and access to the Internet which could enhance the students' problem-solving ability. The laptop students also reported significant more use of their computers in mathematics and social studies classes where teachers might have found it easier to integrate inquiry-based learning activities. Laptop students also indicated they were more frequently engaged in cooperative learning which required students to work and process information together. The combination of these factors may have created an instructional environment conducive to the development of problem-solving skills.

Do laptop students differ from cart students in their mathematics, science, and social studies achievement at the 5th grade level?

A comparison of district benchmark assessments in mathematics, science, and social studies only found a significant difference on the Geometry and Measurement benchmark with a moderate effect size (*ES* - +0.44) favoring the laptop students. Since use of the 4th grade MEAP scores as a covariate addressed the initial laptop student

advantage, the difference is not likely to be attributed to the laptop students just being "better" students. This one significant difference may be due to a variety of factors. It would take multiple years of comparisons to determine if this or other differences are due to the innovation.

In the next section, we will examine the perceptions of the students and teachers related to the use of laptops in the classroom. Data included focus groups, interviews, and surveys.

How do students perceive the use and access of laptop computers?

Survey data from all three years indicated that the laptop students had a positive attitude towards the program. In Year 3, both groups indicated a positive benefit for the 1:1 student-to-computer ratio. However, there were significant differences between the students who owned their computers and had 24/7 access, and those who only had access in the classroom. The laptop students were significantly more positive about their increased computer skills, that learning was fun and interesting, and that the computer provided an incentive to get better grades. Personal ownership led to more individual use of the laptop as well as working in pairs several times each week. The subject areas of computer activities were also significantly different in laptop vs. cart classes. The laptop students responded that they used laptops for language arts almost every day and were more likely than cart students to use them for mathematics and social studies, but to a lesser degree than for language arts. No significant differences between the groups emerged for science. These results suggest that students have a more positive attitude towards the educational benefits of a computer when they own it and have access 24/7 as opposed to having limited access to a school computer.

What do teachers perceive as the benefits and problems of integrating technology in laptop vs. cart classrooms?

The last research question addressed teacher perceptions of the ownership of laptops versus using school-provided laptops. The limited number of responses (laptop = 9; cart = 3), can only suggest trends in teacher thoughts. Consistent with the student responses, teacher perceptions of the benefits of the laptop computers were positive. All the teachers agreed that the 1:1 access increased the students' interests in learning, although, the laptop teachers were in greater agreement that the use of the computers increased student writing and research skills as well as their overall performance than the cart teachers. Laptop teachers were also in higher agreement than the cart teachers that the laptop increased their own personal ability to use computers, integrate the technology, and to use higher-level and project-based learning activities. Last, the laptop teachers may have felt additional accountability to the parents who had to purchase the laptops for their children and gave additional consideration to using the computers every day.

Did the Laptop Computers Serve as a Change Agent?

The results from this three-year study provide three distinct snapshots into technology integration, each with different results. Of primary interest are the teaching approaches and how those approaches affected student behaviors and achievement.

In Year 1, the evidence supports the idea of the innovation as a change agent. There were dramatic differences between the approaches the laptop and traditional teachers employed during the year. The laptop teachers were more likely to use a student-centered approach and methods that were considered best practices. A student-centered approach was not a new concept to the teachers, yet the teachers in the laptop classrooms

were more likely to implement the approach. We believe there were three factors that contributed to the change.

First, two pieces of anecdotal evidence may provide a perspective. The students received their laptops in early July giving them almost two months to explore and learn the Windows interface and to explore Microsoft Office. Two events happened in almost every classroom soon after school started. The first was a technical problem (e.g., “I lost my assignment.”) and second was a student asking how to do something (e.g., “How do I put a picture in my report?”). Teachers soon realized the limitation of their knowledge and readily recognized the knowledge and skills of individual students. Good teachers soon realized they were behind the students’ learning curve and readily adopted a facilitator’s role. When a problem arose, the teachers quickly lost their fear of not knowing and took advantage of student knowledge or the students’ willingness to experiment to find the answer. During a parent meeting, a father who considered himself a power user admitted that he was now learning quicker and better ways of performing routine tasks from his sixth-grade daughter. The 24/7 access afforded by the laptop project provided students with ample opportunity to not only work, but to experiment with their computers. It was not unusual to see a host of customizations and downloads the students had on their computers when visiting a classroom. In contrast is the typical classroom with 1 to 6 computers that students could use infrequently. As a parallel constraint, imagine the effects on teaching, learning, and student engagement of having only six sheets of paper and six pencils in a classroom!

Our second piece of anecdotal evidence comes from a science class. In a traditional classroom, the classroom is defined by the four walls, the textbook, and the

teacher's expertise in the subject. If the teacher does not know the answer to a question, she typically suggests that the student research the answer at the library and report back. While observing a science class, a student asked about the gestation period of a mammal they were studying. Before the teacher could suggest the student do the research in the library, several hands were raised. Students had used their wireless Internet access to search for the answer. Again, the teacher began to facilitate a new discussion as the class topic wandered to a related area.

A second factor that contributed to technology serving as a change agent may have been the change from the teacher as *the* expert to one of a facilitator willing to learn and discover new ideas with the class. The successful laptop teachers readily discovered that the students were able to use their laptop computers in manner different than the traditional textbook. The classroom was redefined from almost the first day of the school year. The laptop classrooms were typically very active. It was not unusual to only hear the teacher address the class one time at the start of session when he would announce "Let's get started." The classroom then became a buzz of activities with small groups of students and individuals spread around the room, some sitting at desks and others working comfortably on the floor.

A third contributing factor may have been the training and support system. The teachers attended training that focused on how to develop inquiry-based units of instruction and how to facilitate the classroom using this approach. The training may have helped them gain confidence in using a new or different teaching method. Similarly, the district administrators provided direct support to the teachers and demonstrated their interest in the project. The assistant superintendent who directed the project maintained a

supportive and visible presence in meetings and schools. Teachers were already use to working in teams and planning their lessons, so this new approach was compatible with their existing framework. As a result, the teams may have provided support and peer pressure for individual members to implement a consistent approach in their team-taught clusters.

Was the Innovation Sustained?

We have defined the innovation in this paper as consisting of two components—the laptop computers and implementation of the NTeQ model. The three-year study examined three different implementations of the innovation. In the first year, the comparison was between the NTeQ trained laptop teachers and teachers in a traditional classroom. It was in the first year that we observed the greatest difference in implementation of teaching approaches.

In Year 2, both groups of teachers had completed training in the NTeQ model. The primary difference was the technology with the laptop classes having a 1:1 student-computer ratio and the CE classrooms having 4-5:1 student to computer ratio (the NTeQ model was developed for this type of implementation). In Year 3, laptop carts were used which provided each student in the classroom with a computer.

Seven of the behaviors observed in the classroom with the SOMs instrument were selected for comparison across all three years (see Table 1). These behaviors are consistent with the NTeQ model and would be expected to be demonstrated by teachers who had completed the training.

Table 1:

Percentage of SOM Visits in Which the Strategy Was Observed Being Used

	Year 1		Year 2		Year 3	
	Laptop	Control	Laptop	Enhanced	Laptop	Cart
Project-based learning	65%	22%	23%	30%	10%	0%
Independent inquiry	58%	24%	37%	22%	50%	11%
Computer as learning tool	88%	17%	66%	17%	80%	100%
Cooperative Learning	66%	39%	22%	17%	10%	11%
Higher level instructional feedback	61%	39%	59%	35%	50%	22%
Teacher as facilitator	72%	61%	56%	52%	80%	78%
Sustained writing	53%	39%	34%	29%	40%	56%

Of particular interest is the use of project-based learning activities since these are the focus of the NTeQ model. During Year 1, there was a significant difference in the observed frequency of project-based learning between the laptop (64%) and control groups (22%). In subsequent years, we would expect to find little if any difference between the groups as all teachers had received the NTeQ training and had access to computers in the classroom. More importantly, we would expect the laptop classrooms to maintain a fairly high frequency of project-based learning. There were no significant differences between comparison groups in the second and third years, however, the frequency of observed use of project-based learning in the second and third years dropped to the level of the control group in Year 1. Since project-base learning is central to the NTeQ model, what was the effect of the lower frequency of use on the related teacher behaviors? One explanation for the higher observed frequency of project-based learning during Year 1 may been due to a Hawthorne effect. The teachers were the focus of much attention during the year and observed frequently by administrators, the research

team, and individuals from other districts who were interested in implementing the project. In subsequent years, the laptop teachers may have lost some of their enthusiasm and started to modify the NTeQ approach to suit their teaching style and needs.

There were six other observed behaviors that are consistent with the NTeQ approach. The laptop teachers maintained a somewhat consistent use of four of these approaches (independent inquiry/research, computer as learning tool, higher level instructional feedback, and teacher as facilitator) during the three years. The observed use of sustained writing and cooperative learning both decreased over the second and third years. During the three years, it appears the laptop and other computer teachers re-invented (Rogers, 2003) the innovation to meet their needs. Conversations with teachers during the third year revealed that modifications in both the training and implementation of the inquiry-based approach as compared to Years 1 and 2. These modifications may explain the drop in project-based learning activities during the second and third year of the project, but the consistent use of other approaches. Comparing the observations in Years 2 and 3 to national norms (CREP, 2006), we found that the laptop, computer-enhanced, and laptop-cart teachers demonstrated these six behaviors more frequently than the national norms suggesting changes in the classroom where teachers were trained in the NTeQ model and had access to computers in their classrooms.

Conclusions

The evidence from this three-year study suggests that a technological innovation can serve as a change agent. We were able to observe significant differences in teaching approaches and student behavior during the first year when the laptop classrooms were compared to traditional classrooms. As the classroom environments became more similar

in years two and three, we observed fewer differences, but we observed consistent use of teaching approaches and student behaviors that were consistent with the NTeQ approach. The results were classrooms that were transitioning from teacher-directed to student-centered classrooms. These results are consistent with those of Johnson, Schwab, and Foa (1999) who also concluded computer technology could transform the classroom.

The combination of the student "owned" laptops and the transformed classroom environment resulted in sustained student achievement. Each year, the laptop student demonstrated significantly higher writing scores than the comparison groups. They had significantly higher problem-solving scores than the comparison groups in Years 2 and 3. In Year 3, we examined the District's benchmark scores and only found a significant difference favoring the laptop students on one aspect of the mathematic exam. It appears the transformed classroom was most effective for developing writing and problem-solving skills. The 24/7 access to the computers may be one contributing factor to this success. Laptop students were able to do their research and write anytime, anywhere. Anecdotal evidence suggests that students often asked teachers for permission to work on projects rather than use free time or lunch time. The sustained writing, which may have been related to their individual research, may have been more engaging than a typical social studies, language arts, mathematics, or science lesson. There is no evidence to suggest that teachers used an inquiry-based learning approach for *all* their lessons. We would suggest that computer technology is not limited to a limited role in student learning as suggested by Cuban (Becker, 2000) .

Other anecdotal reports indicated students applied their writing and problem-solving skills outside the classroom. Several parents reported that their children prepared

well-researched presentations to convince the parents to purchase them a pet, bicycle, etc. For example, one presentation developed to convince the parents to purchase a dog including a list of care taking tasks and projected food costs.

Based on this study, one might ask, is it the case that, even with laptops, teachers naturally begin to gravitate back toward more time-efficient methods than projects and cooperative learning? At the time of this study, State testing was beginning to gain more importance and creating more pressure for students to produce achievement results. Maybe laptops are not a change agent for using less economical teaching methods, but will realistically create more Internet searches, teacher coaching, etc. This adaptation is consistent with Rogers' (2003) reinvention concept where the adopters change the innovation to fit their needs.

We have two recommendations for future implementations of technology initiatives. First, technology hardware should be accompanied with an appropriate instructional approach. Simply handing teachers and students computers without focused integration training does not seem to work. Second, evaluators and researchers should take a systems perspective that is more global than simply considering attitude and/or achievement gains. Studies should be broadened to focus on changes in teacher and student behaviors as well as attitude and achievement changes. Third, a follow up should be planned two to three years after the initial study to determine if teachers are still using the teaching strategies, or if they have adapted the innovation to work with a more traditional framework.

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