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Thin Clients Providing Ubiquitous Technology Access to Support Middle School Students Academic Performance

Case study report by Sara Dexter and Bobby Jeanpierre
U.S.A Exemplary Technology-Supported-Schooling Case Studies Project

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Overview

The innovation referred to throughout this report is thin client computing supporting students academic performance. Teachers at Pine City Middle School are implementing the innovation in grade levels from sixth to eight grade. This innovation is an expression of the district s leadership and technology support as well as the teachers concern to bring students up to grade level in reading and math, and to support students use of an expanded set of ICT tools for learning. In 1997 the district received a grant that began much of the work that led to the current ICT environment at the school. From the start, members of this school s staff have participated in these efforts. The beginning of the 2000-2001 school year marked the full school implementation of thin client computing throughout the school, creating a 2:1 level of access, and 100% staff completion of the year long professional development program.

Teachers use ICT to bring students up to grade level in their reading and math skills, use tool software to complete class projects in a variety of subject areas, and present students with a wealth of internet resources for whatever topic is under study. Within the same period students might use and ICT-based drill and practice program, a spreadsheet program to support their classroom work, or a teacher-made intranet web site to guide their exploration of a variety of Internet resources.

Teachers and administrators in this district view ICT as essential to improving students academic performance. So that ICT use is seamless within the teaching and learning processes, the district committed to providing 16 computers to every classroom and back their use up with quick, service-oriented technical support. All teachers at Pine City Middle School have 12 thin clients in their classroom as well as four multimedia desktop machines, a printer, and a teacher computer station

hooked up to a 27 monitor and speakers. The district s commitment to quality technical support means that teachers usually receive same day service for any technical difficulties they encounter. The thin client model means that these computers are simply serving as dummy terminals for servers centrally located at the district office. As a result, often any problems with these computers can be resolved in minutes of calling the technician. The district has also committed to a yearlong, paid professional development experience for teachers, which all of this middle school s teachers have participated in. The professional development experience is focused on using ICT to help students learn. The encouraging atmosphere allows teachers to begin wherever they are comfortable, some chose to begin with more teacher-centered uses and others with more student-centered uses of technology. Because the administrators encourage sharing and collaboration teachers are able to see new integrative practices without feeling pressure to change their instructional style.

Located in a suburb eight miles outside of the major metropolitan area of San Diego, California, Pine City Middle School, one of two middle schools in this K-8 district, enrolls about 800 students from neighborhood attendance boundaries. The student body is 35% Caucasian, 30% African American and 35% Latino and others. Sixty per cent of the students at this school receive free and reduced lunch.

The Past

The use today of ICT at Pine City Middle School is very much connected to Project PineLINK at the district level. The vision of PineLINK providing a connected learning community focused on improving student achievement (and especially highlighting literacy) provided the focus for Pine City Middle School s efforts to raise students academic performance levels. Therefore, to better understand the evolution of ICT and its uses at Pine City Middle School, it is necessary to begin with the district s ICT work that precipitated PineLINK and how that project contributes to the current ICT infrastructure and goals at Pine City Middle School.

Director of Information Systems Ted Olsen and PineLINK Project Director Susan Hudson explained that the district s current vision for technology supporting teaching and learning began ten years ago. At that time the District examined its overall technology program and began planning how to use technology to improve student achievement. Then in 1993, from the district s general funds, the district put in a centralized 95 foot microwave radio station network, which allowed the initial connection of all the district s schools and the community s libraries. Then in 1995, to save money on human resource information processing needs, they partnered with the city of Pine City. This assisted both parties by making a quality network more affordable and allowed the school district to focus its information technology efforts on the classroom. This literal connection to the community laid the groundwork for their successful 1997 Technology Challenge Innovation Grant proposal, named Project PineLINK, to the U.S. Department of Education.

With the Project PineLINK grant the school district expanded its partnership in the community and substantially increased its technology revenues. A goal of Project PineLINK was that through development of a community Intranet which would provide access to parents of students, community members, city government, community facilities, parochial school, and the local library, web-delivered applications would be available not only to their students during the school day, but to the entire community 24 hours a day (grant proposal site document). The project included many partners, including companies such as Microsoft Corporation and the local cable service provider Cox Communications, as well as city, county, and state agencies, and post-secondary education institutions. This strong group of partners provided avenues for substantial collaboration and support.

In 1998, in order to reduce hardware costs and make quality technology support more sustainable, the Pine City School District decided to implement server based computing and thin clients. As Olsen explained, A thin client itself has no hard drive, fan, or any moving parts; it is all chips. What it essentially does, is it takes over in Windows and key work stations, so when you turn it on, you look

like you are sitting at an [Windows] NT 4.0 or a [Windows] 2000 desktop. All that it is responsible for is transmitting keyboard, mouse, and screen shots over the network. Everything else is happening back here on the central servers. So we put our processing power and our memory and our storage back in one location [the application servers] and we allow these appliances take over virtual sessions. One server can host about 60 users at a time; the district currently has 35 servers in a networked, load-balanced group referred to as a server farm .

The district partnered with Wyse Technology in the development of a classroom-suitable thin client model called a Winterm. A thin client is cheaper than a desktop machine, approximately $300, or about one-third to one-fourth the cost. The thin clients are also easier to maintain than a regular desktop computer. One technician in the district monitors and provides technical support for 2000 thin clients. Besides the ease of technical support and upgrades, Olsen explained some other benefits of the Winterms,

The great thing about the thin client is that...you can t load something on it, you can t steal something from it. It is a worthless device without being plugged into our network. The beauty of it, is that for example when we upgrade from Office 97 to 2000, we did it in four hours on about 35 servers overnight and the next day they turned on the one button that is on that machine, the on-off button. (at405)

By switching to this more inexpensive model, the district was able to provide teachers with a greater number of computers in their classroom and thus ease the amount of instructional planning and juggling necessary when teachers had to use the computers as stations through which the students rotated. Hudson explained, We took four of their CPUs [at that time a total of 8] and we gave them twelve thin clients. So they had sixteen at one time....That totally changed the face of instruction. Also, the move to thin clients meant that the district could economically and efficiently provide this same computer service to homes. The district worked with Cox communication to provide high speed Internet access through the cable TV lines and a cable modem as part of the district s Home Connection program. District students that were considered at risk received free Winterms and Internet access in their homes. Other homes were able to lease the Winterm and receive the network services for a $30 per month charge, which is a self-sustaining rate.

In addition to the ICT infrastructure, staff development was an integral part of the design of Project PineLINK. The objectives for teachers who participated in the staff development training were: 1) to know how to incorporate Internet/Intranet use and quality educational software in the daily activities of the classroom; 2) to understand how to facilitate students access of information worldwide as an integral part of the learning experience; and 3) to learn and adapt new modes of instructional delivery and move away from traditional delivery talk/lecture/dictation approach. To accomplish these objectives Project Director Hudson developed an extensive staff development-training plan. During each year of the five year grant twenty per cent of teachers in the district would be trained. This professional development consisted of a two-week paid summer camp followed by additional sessions that occurred throughout the school year. By the end of year five 100% of the district s teachers would be trained.

Pine City Middle School capitalized on every aspect of the project s professional development and computer access opportunities. In year one, the entire team of Pine City Middle School grade six teachers attended the technology staff development training camp. Since their completion of this training, several of the grade six teachers at Pine City Middle have been instrumental in teaching various classes in the summer technology camp to other teachers. Pine City Middle School teachers aggressive participation in the technology training resulted in all of them having completed the PineLINK professional development by the end of year three. By that same time, through additional contributions from its Title I funding, Pine City Middle School achieved computer equity for all of its classrooms, and at a 2:1 ratio. While the PineLINK project provided the context and opportunity, Pine

City Middle School as a staff took actions to ensure its teachers were equipped with the needed technology skills to effect change in curricula and instruction and that equitable computer access was available to all of the school s students.

The Present

This year, which is the fourth year of Project PineLINK, marks the first full school year that the entire Pine City Middle School campus has a 2:1 ratio of fully supported computers with all teachers having completed the PineLINK professional development on the use of technology to improve students academic performance. This staff preparedness and computer accessibility allows the teachers to use technology to bring students up to grade level in their reading and math skills, use tool software to complete class projects in a variety of subject areas, and present students with a wealth of internet resources for whatever topic is under study.

The tremendous level of student computer access---sixteen computers in every classroom---impacts what teachers can do with them during instruction. But in addition to sheer access, the Pine City teachers found that how the computers are arranged is important for what you can do with them during instruction. In each classroom, computers have been arranged in a configuration called pods. In this pod configuration, three tables are arranged in a T shape. The computers are positioned where the arms of the T meet its body. This arrangement allows two students, one from each side of the computer, to sit at their regular classroom seats and conveniently view the computer screen. So there is no need for students to get up and move to computers that are located in some other part of the classroom---the computers are just a part of the student s regular workspace. This proximity allows the teacher to be sure that students can quickly turn to the Internet as a part of the classroom instruction, and to be able to see close-up any images or text that are pertinent to the instruction, which might be on the teachers classroom intranet. With the pod configuration, in the center of the room there are tables and chairs. When students work individually on the computer, the other half of the class can gather together with the teacher for small group instruction. Together, the T-shaped pods around the perimeter of the room and the center seating area support different configuration for the use of the computers.

This access to and configuration of computers at Pine City Middle School allows the teachers to focus on using technology to improve student academic performance. The most direct method is through the use of the CCC program, a skill development program that Pine City Middle School teachers use in math and reading. The CCC program provides teachers with a means to diagnose and re-mediate students according to their individual levels and areas of deficiencies in mathematics and reading. Sixth grade math and science teacher Barlow explained,

CCC is geared towards that child at whatever grade level they are at, so if a child is working at third grade level they are getting third grade problems that will help build their skills and support them in the regular classroom. And again, I couldn t do that. I couldn t have this child with one activity at third grade level and 29 other students at other stages. (at 408)

The math and reading teachers try to allow for each student to work on CCC a minimum of three times a week for fifteen minutes at a time. The overall number of computers and their arrangement into pods means the teachers need only plan for two different activities, with one group doing CCC and the other completing the other activity, which might be independent work or small group work in the center of the classroom, and then the two groups switch. Teachers commented that this is much easier to plan for than when, previously, they had four to eight computers and had to plan for three to four rotations.

In using the CCC program, teachers are able to differentiate re-mediation for each child. Each child receives additional help on her/his own deficiencies, identified through a CCC administered diagnostic test, without hindering the progress of other students. The CCC program allows students to work independent of the teacher s help, and progress at their own pace. Sixth grade math teacher Barlow explained, So if they see that I am working with someone else, there is a little question mark [in CCC],

and they can click on the question mark and a little tutorial will come and guide them through the problem. With half the class working independently on CCC, teachers have more flexibility to work with the other half of the students either individually or in a small group. Sixth grade math teacher Childs commented, I am available for [helping] them and when they go [back] to CCC [problems] again they are more able to do it....I can [also] spend more time with the group who is at the learning center in the center of the room. Overall, the CCC program gives the teacher helpful information in assessing students progress, and supports differentiating instruction; students get self-paced individualized instruction. Barlow concluded, I really feel like I m meeting their needs and technology is helping to meet their needs in a way that I never could have as a single person.

The Pine City Middle School teachers also use tool software to enrich and extend the teaching and learning process. Teachers and students are using a variety of software including PowerPoint presentations, word processing, spreadsheets, e-mail, and various reading programs such as Accelerated Reader and Readers Workshop. For example, in Barlow s sixth grade math and science class students were preparing an 18-slide presentation of their science biome project. In Childs s sixth grade math class students were using a spreadsheet to learn about formulas in mathematics. Students especially enjoyed the ability to e-mail their friends, and they could also use their e-mails to communicate with their teachers about homework. One student enthusiastically commented, You can send a project to your teacher through e-mail. In addition, students use teacher-made intranet web sites, which allow teachers the capability to create their own curricula and present it as a web page. For example, they might organize a group of Internet sites, and add instructions that guide students through them, explain assignments, and post daily agendas. Ortiz commented, Using a web site has allowed me to put [in the intranet site] anything I create, to link it in, and I ve got it in the future. This allows students to stick to pertinent, teacher approved sites as they proceed somewhat independently through material, which can allow the teacher the possibility of working with a small group in the center area of the classroom.

Students who have the district-supported PineLINK Home Connection can access these intranet sites at home, as well as other Internet resources, all the tool software, and complete CCC practice strands. Currently, nearly 300 families of Pine City district students have the Home Connection. The Home Connection also allows parents to go to the teacher s web site to obtain students homework, the teachers lesson plans and daily agendas. Pine City parents who selected this home computer connection have access to an additional tool to assist them in communicating to their children s district, school, and teachers.

The district s ICT infrastructure provided Pine City Middle School s teachers with the necessary technology training for them to direct these resources towards raising students academic performance. All mathematics and reading, language arts teachers at Pine City were trained in how to produce and interpret students CCC progress reports. These reports provide important student progress information that teachers may use to assist them in planning individual remedial work. Students progress on math and reading skills are important for their success on the State required SAT9 test. Thus, CCC reports help teachers know where students need additional help. Principal Green explained, It [the standards and accountability movement in California] is a tremendous influence. It dominates our conversation. There is no question about that. It s something the State is saying, this is what our expectations are as a school. That carries a lot of weight. There is no question about that. A school s students scores on the SAT9, along with the State s supplemental test (together these are called the STAR test), determine the school s API (Academic Performance Index). This API academic growth score is used to determine the school s statewide ranking. Each year the school is given a target percent that they are expected to raise their API. The teachers ready access to student achievement progress data is important in their being able to be proactive in addressing students testing and learning needs.

In addition, all teachers at Pine City Middle School have received professional development focused on learning how to use various software programs and developing curricula lessons integrated with

technology. The staff development documents listed training sessions such as, Technology in Literacy-based Curriculum, Developing Standards-Based Projects Using Technology in the Primary Grades, Building a Classroom Intranet to Deliver Instruction, Microsoft Office in the Classroom, CCC Reading Adventures, and PowerPoint/Digital Camera Revisited. A two-week summer staff development kicks off their PineLINK training and then the teachers continue with a yearlong follow-up. PineLINK Project Director Hudson recalled that they felt they needed to ...look at a way to really come up with a program that could train teachers appropriately....[or] We would never be able to support this [technology] as an expectation to improve student achievement....
Another important aspect of the school s technology environment is the high quality technical support they receive from the district. The district technology personnel explained that they wanted to free teachers of dealing with technical support problems, so that they could begin thinking about how to use the technology in their curriculum to improve student achievement. Teachers are extremely complementary about the level and quality of technical support that is readily available. Seventh grade social studies teacher Banovetz commented,
Yes. In terms of just maintenance of computers, that s key. I have sixteen computers in my room, and if something goes wrong, I can pick up the phone, call the technology department at the District office, and know that someone, if it is a serious problem that s blocking my students [progress], somebody is going to get on it pretty soon. Often times within that class period.

In conclusion, Pine City Middle School has achieved equity throughout its classrooms with a 2:1 fully supported computer student ratio, employed specific curricula-instructional technology supported strategies to improve student academic achievement, provided 100% of its staff with technology training and support, and has sought to improve home-school communication through its involvement in the district supported PineLINK home-school connection program.

The Hypotheses

Hypothesis 1:

Technology is a strong catalyst for educational innovation and improvement, especially when the World Wide Web is involved. The rival hypothesis that where true reform is found, technology served only as an additional resource and not as a catalyst, that the forces that drove the improvement also drove the application of technology to specific educational problems.

Evidence in support of rival hypothesis:

The evidence indicate that there was more support for the rival hypothesis, that the need to improve students academic performance, particularly in reading and math, was the catalyst for the current uses of ICT; thus, technology served as an additional resource for their efforts. The school s, improvement effort (shared by other schools in the district) was determined by their need to improve their API (Academic Performance Index) score. This measure, developed by the State as an overall measure of the school s students academic growth, is currently based solely on the SAT9 test scores. The API and the expectation that schools annually meet their improvement target (created by a formula that includes weighting lower scoring students improvements more heavily) was a state policy that influenced the scope and direction of the school s, and district s, improvement efforts. In addition to this state policy, at the school level the teachers realized that they had students who struggled academically. Hence, Pine City implemented a variety of strategies that could improve their students academic performance, and as a result their SAT9 scores and the school s API score. The school adopted a combination of technological and non-technological strategies for improvement.

One non-technological improvement was the Power Math and Power Reading selectives, which students with the lowest SAT9 scores were required to take. These classes were designed to assist low-skill level students improve their reading and mathematics skills. These selectives were in addition to the students regular reading and math classes and focused on catching them up to grade level through direct instruction, activities, and the use of technology-based skill programs, which were also used in regular math and reading classes.

Evidence in support of hypothesis 1:

Within the context of improving students academic performance, the ICT the Pine City Middle School teachers were able to use did provide unique capabilities for them, serving as a catalyst for the particular approach they school used to define progress and readiness. The CCC program was the primary technological method that teachers used in math instruction; in reading instruction teachers used CCC as well as Accelerated Reader and Reader s Workshop. As the Principal put it The technology helps to create a data leap. It is an interim assessment tool, and helps us to see progress in small pieces. The CCC program provided students with regular 15 minutes intervals of skill-based practice in reading and mathematics. The reading programs encouraged kids to red books by selecting titles that matched their reading level and interests, then allowed them to earn points when they answered questions correctly about their content. In addition, the various tool software extended and enriched teaching and learning opportunities. The district s PineLINK home connection provided parents with a low-cost computer and Internet service plan that enabled them to have in-home computer use and support, and 24 hours a day, 7 day a week access to school and class information and curriculum, including the CCC program.
The PineLINK infrastructure was an important catalyst for the school s capability to apply technology toward improving students academic performance in that it provided training in the use of ICT, technology support, and ubiquitous classroom computer access (at a 2:1 level) to all district teachers. PineLINK also provided the CCC Program training to the reading and mathematics teachers.

Hypothesis 2:

The diffusion of the reform (and therefore of ICT) followed the traditional diffusion pattern for reforms and innovations, as outlined by Rogers (1995). The rival hypothesis is that technology functions differently from traditional innovations and reform and that therefore different diffusion patterns occur.

Evidence in support of the rival hypothesis:

The PineLINK project was planned so as to allow for eventual 100% participation by the district staff. While the choice of when to attend over the five-year life of the project was described as voluntary, the project director and principals encouraged people to attend at certain times. For example, all of Pine City Middle School s staff had completed the training by the third year the training was offered. The goal of 100% district participation necessitated that all teachers could successfully implement technology in their classrooms within this time period; the district also sought to deploy technology in a particular pattern. For both of these reasons, the project director designed the training so as to allow the innovation to spread according to their plans, and not according to the diffusion model.
Their design emphasizes that learning to teach with technology is an evolutionary process, and that in order for teachers to learn, professional development programs must create a positive learning environment for teachers, one that addresses their needs, concerns, and provides appropriate supports (including emotional, collegial, and technological support). This design was premised on Sandholtz s work from the Apple Classrooms of Tomorrow (ACOT) project, which bears much similarity to Hall s (1977) Concerns-Based Adoption Model (CBAM). Both of these models address how to design an

implementation process so as to overcome the likelihood that some individuals are more inclined towards an innovation, and others less so, which is the premise of Roger s diffusion theory (1995). Project Director Susan Hudson explains how Sandholtz s work influenced their attitude for how to get things started,

...when people understand it s a process, you can be anywhere on that process and not feel that you are left out....Everybody can do it. You can start here, or you can be there. But we are all on this process and moving along and we are going to help each other to do that. So we had to build a mind set and get a team of teachers going. The first group [PineLINK 1] became very involved. They took the torch and they were out there on each site.

Hudson explained that two other premises influenced whom they encouraged to volunteer for the first and second years of training. First, they didn t just want the techies, or people who would be perceived as more inclined towards technology and possess some obvious advantages for successful integration. Hudson explains, when you get good strong regular people on [board] there and they are using it effectively and they love it, that is a testimony for the rest. And that [testimony] is really what started bringing the rest of the groups along. Second, they wanted teachers from every school and from strategic grade levels. By beginning with kindergarten and first grade teachers, and fifth and sixth grade teachers, it would allow students to have a learning experience with consistent educational technology resources. They would move from fifth grade into a middle school classroom with classroom technology. Then, in the middle years of the project they would get seventh and eight grade teachers involved. Hudson explains that this strategy allowed a consistency in learning with kids, and we d see really what happened to that child that started with us in Kindergarten with computers and by fifth grade what would that child look like.

While their implementation approach was designed to make the innovation spread in a particular way, the project staff anticipated that by the last two years of the project that they might encounter what Rogers describes as later majority and laggard adopters. Hudson explained that their expectations had been pleasantly exceeded:

We thought groups one and two would be terrific. We thought we would have enough techno excitement going that we could generate two groups....We thought [year] four and five [participants] would be career busters and probably quite difficult to manage. Last summer, [year four] we did it by volunteers. We didn t say [to those remaining] that this year you are going to do it. The group four volunteers---I had more people volunteer than I could take....Next year, we already have people lined up for fifth year. Everybody is doing it. The teachers are talking,..."you know everybody who is anybody is doing PineLINK.

The project director s comments were consistent with those made by teachers at Pine City Middle School. For example, the sixth grade team of teachers (between 9-11 people) participated in PineLINK the first year. We observed and or interviewed four of these teachers in depth. One of them indicated that without the team approach, she never would have chosen to participate the first year. She indicated that she was not a risk taker, and hadn t previously known how to use a mouse. For her, the project design provided the support and push she needed to be successful:

The sixth grade team getting together and sharing...we did a lot of informal sharing, and I can t stress strongly enough, how valuable that was for us to go through as a team, to work together, to learn together and to be sharing. To me that was everything. I think if I had been in a group, where I was at this school and someone else was over there and another was at a different grade level and this one taught a different topic, I don t think there would have been that kind of bonding and sharing that went on. I really think that s what has pushed us and made us grow.

Evidence in support of hypothesis 2:

Because the PineLINK implementation pattern was planned, it did not follow the traditional diffusion pattern. But nonetheless, there were elements of the teachers; differing levels of readiness that Rogers refers to in his model. For example, three teachers from this same sixth grade team were clearly technology leaders for the school; even before PineLINK began they had been involved in technology pilots in the district. One in particular was uniformly acknowledged as a technology innovator at the school. Another of these teachers, a sixth grade science teacher, explained that it was the pioneers who are inventing new uses but PineLINK closes the gap so that people try.

Hypothesis 3:

Successful implementation of ICT depends mostly upon staff competence in the integration of ICT into instruction and learning. This hypothesis assumes that teachers mediate ICT applications when they are successful, and that ICT s academic value relates positively to teacher competence. The rival hypothesis is that the school technological infrastructure and student ICT competence rather than staff competence determine ICT implementation outcomes.

Evidence in support of hypothesis 3:

The district s vision of teachers of teachers using technology to improve teaching and learning was supported by summer technology learning staff development and sessions throughout the year. Ortiz commented, I mainly used technology...preparing materials, making master overheads that I wanted to use, or using Power Point presentations that you would use periodically in class. In addition, to instructional uses teachers also create their own curriculum. Ortiz stated, Using a web site has allowed me to put anything I create, to link it in, and I ve got it in the future.
At Pine City, teacher collaboration on technology use is a part of the school s teaching culture. The principal commented, They share curriculum, things they have developed through the Internet, or web pages they have for their class.

Evidence in support of the rival hypothesis:

The PineLINK infrastructure, clearly, contributed to teachers having sufficient access to computers for classroom use. The increase in numbers of computers from four to eight, to the current number of sixteen, has facilitated teachers using computers more. Barlow commented, When we had eight it was more of a turn kind of thing....So with sixteen, I mean its theirs, it s like having a pencil in your hand or a book at your desk, it s just anytime you need it, it s there. With sixteen computers per class, teachers now have the flexibility that need to have technology as an integral part of instruction. Another teacher, Ortiz, commented, Technology is no longer a center you go to. It really became a central part of the classroom.
In addition, the PineLINK home computer connection gave students accessibility to the CCC program in and outside of regular scheduled class time.

Hypothesis 4:

Gaps in academic performance between high and low poverty students will not increase when all students have equal access to ICT. The rival hypothesis is that equal access to ICT will lead to more advantaged students increasing the performance gap with disadvantaged (high poverty) students.
The free and reduced lunch rate in the district is 57% and 60% at this school, indicating that a majority of the students in the district and school are from families with low incomes. In 2000 the district compared the 1999 and 2000 SAT9 reading and math test scores of sixth grade students who had twelve or more hours of documented computer use focused on structured reading and math skills

development applications with those who had a lesser number of hours of use. However, these scores are not disaggregated by income level or school attendance site (there is another middle school in the district in addition to the one we attended). These results make it difficult to address either hypothesis directly.

Evidence in support of the hypothesis 4:

Nevertheless, the data below do show the positive impact of this particular type of ICT upon student achievement performance, as measured by the SAT9 standardized test. That these students are scoring better than their peers does indicate something positive about the role of ICT in improving achievement levels of mostly low-income students, at least on this measure (see Table 1).

Table 1
Comparison of percentile point gain on SAT 9 mean scores for participating and non-participating students.

	Percentile point gain on SAT 9 reading subtests	Percentile point gain on SAT 9 math subtests
PineLINK participants	5	19
Non participants	2	11

Evidence in support of the rival hypothesis:

We cannot speak to this point.

Hypothesis 5:

Successful implementation of ICT will lead to the same or higher academic standards in spite of the low quality of many ICT materials. Academic standards are a function of teacher and school expectations and not of the standards of textbooks, ICT materials, and the like. The alternative hypothesis is that ICT use will lead to a lowering of academic standards as students spend more time on marginally beneficial searches and in browsing poor quality web and courseware content.

Evidence in support of hypothesis 5:

The ICT software at Pine City Middle School is a combination of drill and practice software, and tool software (such as Web browsers, and word processing). Teachers shared observations with us that each type of software, in its own way, contributes to student s reaching higher achievement standards, or acquiring new skills.
The drill and practice software used at the school is CCC, which serves as a diagnostic tool to determine if students are at the standard of appropriate grade level skills. At this middle school it is used only in reading and math. When students first log in to CCC, they answer a series of questions that diagnoses their capabilities in the topics, or strands, that the teacher has chosen for inclusion for the reading or math class. This provides, as a three-digit number, a baseline score for the student; the first digit is the grade level, the decimals represent months of progress in that grade level. For example, in the middle of the school year a 6th grade student whose reading level was 5.50 would be considered

a full grade level below where he or she should be. At Pine City Middle School students typically practiced on CCC 3 times per week, for 15 minutes per session; at any time the teacher could request a report to review the student s level and see if they d made progress toward where they should be. Students progressed in their score not by just answering an overall number of questions correctly but by answering correctly a certain percentage of questions on the topics keyed to that grade level in the strand areas selected by the teacher. The program notified the students when they progressed to the next higher level.

Teachers and administrators described to us and presented CCC printouts that demonstrated the progress the majority of students were making to improve their reading and math skills. Descriptions of students raising their scores 1 to 2 grade levels were not uncommon. In other cases, the gains were smaller or the students simply progressed in accordance with their grade level status. The feedback from this drill and practice software clearly serves to notify teachers as to students progress toward and to motivate students to progress toward the standard of age appropriate skills in math and reading.

The tool software students used in class, and the way assignments, based on state curriculum standards, used ICT, allowed students to demonstrate to their teachers that they not only fulfilled the assignment requirements but that they acquired new skills. For example, students were very adept with their ICT skills; they not only learned the programs but also gained a familiarity with technology that allowed them to quickly pick up new programs. Teachers sometimes assigned projects that could capitalize on the Internet and software tools. For these, students often were assigned to work in groups, where they divided up tasks and had to collaborate in order to be successful. Many projects involved a research component, which required students apply information skills successfully. The software-based products also allowed students to easily edit their work, which one teacher indicated was more often done now than previously with paper and pencil products.

Teachers were very conscious of students not spending precious learning time on poor quality Web sites or courseware materials and took actions to guard such waste. For example, one of the sixth grade teachers pre-selected his web sites for students use and then authored his own web pages, in order more easily keep students at appropriate, high-quality sites. This approach was evidently desirable to other teachers as several others at the school had started to do it as well and the PineLINK project planned to offer training for teachers to learn to start a class intranet, as they referred to it. In addition, the district used Internet filtering software to keep students away from inappropriate sites. The teachers also had to be vigilant for students thwarting the potential of the CCC program to provide practice and assessment about their knowledge. Some teachers reported that during math, occasionally they would have to tell students to put away the computer s on screen calculator, which was allowed for some problems but was inappropriate for use with other computational problems.

Evidence in support of the rival hypothesis:

None.

The Future

While the federal Technology Challenge Innovation Grant PineLINK, E-rate funding and Title I funds have provided substantial monetary resources for this district and school, the project directors and administrators have taken care from the start to ensure the district can sustain providing access to current technology and reliable, readily available quality technology support. As a school, Pine City Middle School is well positioned to build upon the district s provisions and sustain their particular technology integration efforts. The State s standards and the related policy environment will likely help to sustain the district s and school s focus on student achievement.

In 1997 a federal grant award provided $5.2 million dollars to the district over a five-year period and

an E-rate grant provided another $1.2 million dollars. These monies allowed the district to invest further in its infrastructure, purchase additional hardware, hire staff for the technology integration coordination, and provide teachers with training, which they are paid to attend. From the outset, the district has been planning its expansion in a way that will allow them to maintain the network and school computers. They have done this through purposeful planning and establishing partnerships.

The school district is its own Internet service provider, which saves on some reoccurring costs. In addition, they provide network services to the city for a fee, which helps them to recoup some costs. The thin client is cheaper than a desktop machine (about $280), and its technical support (both maintenance and upgrades) can be done from a centralized location. Currently, the 2000 thin client machines are maintained by one full-time technician, in contrast to the 4 technicians they have on staff to support their 1800 desktop machines. The district s Director of Information Services Olsen surmised that, considering both support and hardware costs, their move to thin client reduced the cost of putting a computer in a classroom to about a third and ensured they had a sustainable model for technical support. Each year the school board has expanded the district s share of the technology budget so that at the end of the PineLINK grant, they have a sustainable hardware, network and technical support system. Olsen also added that centralizing on software titles ensures they get the best price possible and allows them to focus in their professional development programming on depth instead of breadth.

The district wide current level of an initial 120 hours for each teacher of paid professional development, plus follow up opportunities is unlikely to be sustained after the grant money ends. Although, the principal of Pine City Middle School stated that since theirs is a Title I school, because of the low income levels of the students families, they could, in the future, plan to provide teachers with paid time for further technology professional development.

Other conditions at the school that contribute to sustainability of its teachers using technology to support student achievement are its grade level teams and the collaboration across these teams and throughout the school. As discussed earlier, the teachers at a similar grade level usually went to the PineLINK summer training as a group. This learning helped to establish a common knowledge base and got them in the habit of sharing ideas electronically, which was reinforced by during the year follow-up sessions, which are organized by the PineLINK Director. At the school, the teachers are in grade level teams that meet to discuss curriculum and other issues at that grade level. These team interactions are in addition to twice or so a month whole staff meetings and occasional minimum days where students are released early and teams or the whole school can work together. At the staff meeting we observed, a majority of the time was spent discussing an instructional concern of the staff; the principal indicated that oftentimes the topic of discussion, or perhaps a demonstration, was technology.

The State s policy environment and accountability movement will sustain the district and school s focus on teaching to standards and students achievement of them. The school principal stated that the standards movement a tremendous influence. It dominates our conversation. ...Our job is to look at that huge list of standards and expectations...and say OK, these are the things that we need to address.... As he went on to explain, this would be an easier task if the assessment or State test were closely aligned with the standards,

What we teach, what we test, what we are evaluated on, have not always been in alignment. So the aligning piece is something we are really working on....What we are trying to do in the District is to distill down [the list]---at least maybe look at it almost on a thematic level, whether we are going to looks at some essential standards or essential learnings. Just say, these are the things that we really have to be sure that we focus on. (Principal, at0405)

There is a high stakes test, the SAT 9 required by the State; it generates the API score that the school is expected to raise each year. These scores are published and schools that do not meet their targeted 10%

rate of improvement on the API are given warnings and a timeline to improve. Thus, the policy climate is such that the district and school will likely stay focused on student achievement and given their significant investment in technology will continue to apply technology to this cause.
The transferability to other schools in this district has been underway since the funding began in 1997. The transferability to other districts would require strong district leadership and technical knowledge. There are eight schools in this lower secondary district, including six elementary schools and one other middle school. Pine City Middle School is slightly ahead of others, with 100% of their classrooms at 2:1 computer access and all teachers trained, because they chose to use their Title I money to accelerate the grant s planned implementation schedule for their site. By the fifth year of the grant, the 2002-3 school year, all district classrooms are planned to have similar access and all district teachers will have participated in the PineLINK training.
This district s model of using thin client to increase the overall number of computers available in classrooms poses some challenges for transferability of this strategy to other districts or schools. A thin client model requires a high-speed network (i.e. T1 or greater), servers with the necessary software to run server-based application computing, specific technical expertise to set up the necessary infrastructure, and technicians with skills at least equivalent to Microsoft Network Certification. Olsen, this district s Director of Information Services, has kept up to date in the technical developments in his field and has sought out business partners with whom to innovate on the deployment of this strategy in the district. His assessment of the transferability of this strategy to other districts is that it is possible, but requires careful planning. School districts can hire consultants to help them design the implementation. He acknowledged that after factoring in the upfront costs of hardware and software, infrastructure, training or consulting, and servers, in order for a district to see a cost savings, as compared to going with desktop stations, they would need to be interested in deploying about 500 thin clients. This level of commitment could deter other sites from using the thin client strategy. He added that if schools are simply interested in using thin clients to replace aging desktop machines in labs, they may not have a need level that reaches the threshold where they will see cost savings; also, because thin clients cannot accommodate CD-ROMs or disks, they may not be suitable as the only type of machines in computer labs.

Appendix A Methods

Research Team: 2 researchers

Time Frame: 5 consecutive school days

Data Collected:

- **Interviews (30 90 minutes)**

District Technology leaders (2)
School Principal
School technology leader
3 grade six teachers
3 grade seven teachers
2 grade 8 teachers
1 special education teacher
1-second language specialist

- **Focus Groups (30 - 60 minutes)**

4 grade six students
3 parents

- **Observations (approximately 90 minutes)**

2 grade six classrooms,
2 grade seven classrooms
2 grade 8 classrooms
Grade 7 and 8 students in Web Media Communication Class
Teachers and principal during an after school staff meeting
Tour of district network system facility

Appendix B: Teacher ICT Practices Survey Results

Site 400 N=35 teachers (of 35 teachers)

How comfortable are you with using a computer to:

	very comfort-able	comfort-able	somewhat comfort-able	not comfort-able
	%	%	%	%
Write a paper	91%	9%	0%	0%
Create, maintain web pages	26%	6%	29%	40%
Send & receive e-mail	94%	6%	0%	0%
Programming	3%	3%	11%	83%
Draw picture or diagram	31%	14%	37%	17%
Present information	66%	11%	20%	3%

For work you assigned last year, how often did your students:

	1+ times weekly	1+ times monthly	a few times	never
	%	%	%	%
Use WWW	23%	29%	40%	9%
Create web pages	0%	3%	23%	74%
Send & receive e-mail	26%	9%	20%	46%
Use word processing	24%	29%	38%	9%
Use computer for games	9%	6%	46%	40%
Use a graphics program	3%	11%	34%	51%
Join on-line forum or chat	0%	0%	6%	94%
Use presentation program	9%	29%	49%	14%
Use instructional program	37%	14%	31%	17%

Rate your ability to use a computer

	good	fair
	%	%
Ability to use compute	66%	34%

Experiences last year

	yes	no
	%	%
Graded student computer use	54%	46%
Made Web site for my class(es)	50%	50%
Involved in virtual, on-line course	21%	79%
Students collaborated via Web	18%	82%

How much freedom did you allow students in locating WWW sites to visit?

		no restrictions	some restriction	Only certain sites
Students' web restrictions	Count	4	14	8
	%	15%	54%	31%

Computer use in classes last year

	All	Most	Some	Very little	None
	%	%	%	%	%
% of classes devoted to computer use	39%	45%	10%	3%	3%
% of computer use done individually	16%	58%	19%	3%	3%

Computer use at home

	1+ times weekly	1+ times monthly	a few times
	%	%	%
Amount of computer use at home	63%	23%	13%

Collaboration with other teachers via WWW

	yes	no
	%	%
Using ICT for collaboration	58%	42%

E-mail messages sent daily

	12+	6-11	1-5
	%	%	%
Daily e-mail messages sent	10%	45%	45%

Computer Expertise Index

	none	1	2	3	4	5
	%	%	%	%	%	%
Number of computer activities done	13%	19%	23%	19%	6%	19%

Appendix C:

No supporting evidence to include.