Mantua Elementary School
Case Report from the
U.S.A. Exemplary Technology-Supported Schooling Case Studies Project

Mantua Elementary: A Basic School Powered by Technology

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IEA's *Second International study of Technology in Education* (SITES) consists of three modules. SITES Module 2 (M2) is an international qualitative study of innovative pedagogical practices that use information and communication technology (ICT). The final project report and cases from participating countries can be found at http://www.sitesm2.org/	The OECD case studies project, *ICT and the Quality of Learning*, is a major international initiative organised by the Center for Educational Research and Innovation (CERI) within its work on Schooling for Tomorrow. This initiative is concerned with the profound implications that ICT has for education and learning and involves many of the 30 OECD member countries. The final project report and cases from participating countries can be accessed at http://iol3.uibk.ac.at/ICTandSchooling/caseStudies/

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Mantua Elementary: A Basic School Powered by Technology

Case Overview

Mantua Elementary School provides general and gifted education for 799 neighborhood students in grades K-6 and specialized education for deaf and hard-of-hearing children age 2 through sixth grade. The school is located in Virginia, in an upper-middle-class community within commuting distance of Washington, DC. The student body is 3% black, 6% Hispanic, and 19% Asian, with 8% eligible for free and reduced lunch.

The major instructional innovation supported by technology at Mantua is the One-to-One program, which provides every fifth- and sixth-grader with full-time use of a laptop computer. Through the school's partnership with Bell Atlantic, Mantua has also developed a comprehensive distance learning program and an on-site video production facility.

Mantua received a community grant in 1997 that helped it establish the integral use of technology throughout its instructional programs, including the Total Communications Center for the Deaf. The school adopted an integration model described by the late Dr. Ernest Boyer in his report *The Basic School: A Community for Learning*. These integrative priorities are intended to provide support for the learning of the whole child throughout the whole school: the school as community, a curriculum with coherence, a climate for learning, and a commitment to character. The Boyer model provides Mantua with a way to measure whether the integration of technology is consistent with the overall beliefs and goals that the school has subscribed to.

As a consequence of technology's integral role at Mantua, the innovative instructional use of technology is prevalent throughout the school and includes classroom computers, a technology computer lab, a distance learning lab, a closed-circuit TV production studio, and student use of wireless laptops, Apple eMates, and AlphaSmart word processors.

Implementation Context

History of the Innovation

The Basic School philosophy and the school's focus on technology are ideas that emerged during the same school year in the late 1990s. The staff was already engaged in an exploration of the Basic School philosophy when they were prompted to explore goals for the use of technology at Mantua. This pivotal point stemmed from the receipt of $600,000 in settlement funds from Texaco in 1997 in compensation for an oil spill in the neighborhood. To receive these funds, the school had to provide a thorough, concrete technology plan. Because these two explorations occurred jointly, the use of technology is not an add-on or isolated concept at the school.

In their technology planning, the staff at Mantua found that it was far easier to buy hardware and software than to envision how these purchases could improve learning. After spending about half of the money on classroom computers, wiring, and teacher training, the remainder was left

to collect interest for a limited time period while a team of administrators, teachers, and community members continued to develop the vision for technology use.

The school's first technology specialist came to Mantua at that time and joined the technology committee and a Basic School reading group. She is cited as the person who was instrumental in helping others determine what role they would like technology to play at Mantua. At a meeting of the technology committee, she asked them to "envision a school where money is no issue and what do we want teaching and learning to look like, what do we want our classrooms to be." She says that as teachers envisioned what they wanted their students to be able to do more broadly, the specific technology needs were defined as part of that vision. She found that, gradually, the same needs were being defined at Basic School reading group meetings in their discussions of what would happen in the ideal school. Ultimately, the staff felt that the two threads came together, and the school's vision was clear: a Basic School with an emphasis on using technology to support learning.

The initial purchases made with the Texaco funds reflected many school's technology plans: the infrastructure to support four computers in each classroom and training in their use. The vision developed at Mantua, however, extended to the concept of one-to-one student-computer access. In their "money is no issue" exercise, staff were concerned that learning experiences could be limited by the extra organizational efforts required by teachers when students must share computer access. It is often suggested that having computers in each classroom is preferable to school computer labs, and many schools aim to equip all classrooms with at least a few computers, but most schools do not attempt to achieve one-to-one access. The one-time funding from Texaco made it possible for Mantua to adopt the one-to-one strategy.

The distance learning lab was built with funding from Bell Atlantic. It consists of closed-circuit television production equipment, housed in a studio and control room, and a Tandberg Educator 5000 system for videoconferencing, housed in the studio. The distance learning lab is capable of communicating via either H.323 (for Internet) or H.320 (for ISDN) connectivity. Use of the lab is intended to support student collaboration and prepare them for mobile and remote workplaces in the future. Another important goal for the lab is to provide visual access to the deaf and hard-of-hearing students. These students are able to share in the morning announcements through the visual medium of television. Not only is the news program signed as well as spoken, each day a new hand-sign is highlighted to improve the communication between hearing students and deaf students.

Mantua houses a Gifted and Talented Center that draws identified gifted students from a number of neighboring elementary schools. Currently there are two third-grade classrooms, one fourth-grade classroom, and three fifth/sixth multiage classrooms, with a total enrollment of 135 students. Students in the GT Center study the same Fairfax County Program of Studies curriculum as do students in the base school with instructional techniques that are designed to match the educational learning styles of gifted students. All GT students are instructed one year ahead in math, with the intended goal of taking algebra in seventh grade. Additional language arts, science, and history units for gifted students, designed by the College of William and Mary's School of Education, and the Challenge Math Program are part of the enriched GT curriculum

The use of computer technology by Fairfax County students, teachers, and administrators to communicate and access information has increased significantly during the past year. The number of file servers in Fairfax County's 238 schools increased during the 2000-01 school year to more than 700. The school division migrated from multiple e-mail systems to a single e-mail system in 2001. E-mail has become a mission-critical application for teachers, administrators, and parents, providing ease of communication and collaboration opportunities. School-based technology support was a focus for 2000-01 technology spending. All classrooms are wired for Internet connectivity, and the final phase of Internet content filtering was completed. The number of network devices (computers, printers, etc.) has exceeded 70,000. During the 2000-01 school year, approximately 3,000 additional computers were provided to schools to support key instructional programs. Laptop wireless labs were added to classrooms, and several successful pilots were completed at all school levels.

School Culture, Professional Community

Fairfax County is a highly regarded school district that can attract good teachers. At Mantua Elementary there were 62 specialist or classroom teachers and three administrators who were supported by 3 technology specialist positions, and fifteen instructional assistants. The school also houses the Mantua Center for deaf students from across Fairfax County and other counties as needed (73 students), and a Gifted and Talented program (126 students).

The study of the Basic School philosophy was not mandated from above but began when some interested teachers began a reading group, "Breakfast with Boyer," to study the Basic School approach. Other teachers joined them as their interest was piqued. The technology coordinator explained that the decision to become a Basic School evolved from reading group discussions that eventually involved most of the teachers at the school, as well as some parents:

> We had started a teachers-as-readers group, to look at the Boyer book and talk about the implications, and we called that "Breakfast with Boyer" and the word got out after the first session. The first session we had, it was so exciting and it was so refreshing for a teacher to be involved in professional dialogue with peers. We were hearing from a kindergarten-first-grade teacher, and a third-grade teacher, and a sixth-grade teacher, and when you're at a grade level and immersed you hear what you think at that grade level. But, hearing everyone come and be talking about teaching and … it was just … so the word got out and the group grew exponentially. I think by the time we got to our third chapter, or maybe the fourth, almost all of the staff was there, it was just remarkable.

The discussion groups focus on the four components of the Basic School: community, curriculum, climate, and character. The Breakfast with Boyer meetings are still held twice a month—one time for the full staff, the second for just the new teachers.

The school's use of technology was the result of several years of intense focus on the purpose and goals of both the school and the use of technology in education. Having all of this technology available puts Mantua ahead of many schools in the nation in terms of access. However, the staff members are quick to point out that the satisfaction in having all that technology comes from the school's success in integrating its use to support learning. Teachers experienced with using technology say that it is now hard to separate thinking about technology

use from thinking about instruction; for them, technology and instruction have become seamless, and use of technology occurs naturally as they plan instruction. They do not make use of technology for its own sake but include it when it will support learning. Still, the staff members see themselves as learners and devote professional development resources to technology. Every year, there are new teachers to introduce to the use of technology and there are new technologies whose uses in the classroom need to be explored. The staff culture is remarkably collaborative and open, and teachers primarily turn to each other to learn how to use technology effectively in the classroom.

The willingness of Mantua's teachers to learn to use technology effectively and their support for each other's efforts has been a critical factor in the successful implementation of technology. Resources listing steps for effective integration of technology into instruction do not yet exist, and so teachers at Mantua had to learn much of what they know about its use by trial and error and by sharing their experiences with each other. Support from the school's administrators in the form of scheduled meetings of various teams of teachers provided the forum for teachers to build and share their knowledge of technology use.

> Coming into this school, I thought I was highly competent in technology until I saw how it was being utilized … the children are immersed in it, completely, so for me to step into here, I really relied on my teammates. Some of the teachers, and one that had retired last year, was very helpful in explaining how to utilize the technology, and how to create lessons. That's one thing, when I came in with little expertise in, not just using the technology … as a reinforcement tool … but as a means to the lesson, to the creating and the implementing of learning. And that's mainly occurred through my teammates and other experts within the school.

Teachers' team meetings have also been a critical source of support for the integrated use of technology. Weekly meetings for the One to One program teachers were initiated when the eMates were purchased. These and other team meetings provide a forum for teachers to discuss appropriate uses for technology in different subject areas, and to give each other technical assistance with the use of specific pieces of equipment. The principal explained that the meetings also serve as the forum for dealing with the process of change, so that teachers do not feel isolated when they are trying to do something new in the classroom.

The school's principal prior to the 2000-2001, the school year of our visit, was recognized with the Distinguished Principal award in 1999 by the National Association of Elementary School Principals (NAESP). She left Mantua when she was promoted to director of the district "pyramid" program, which the county school district has established explores ways to replicate Mantua's success throughout the rest of the school system.

The current principal, who began as a teacher for deaf students, is fully supportive of the pervasive use of technology throughout the school and encourages new teachers to seek the assistance of the technology specialists. She has encouraged the staff to apply for grants to explore best practices in early childhood education, host graduate-level courses on-site, develop their own integrated curriculum, and work closely with parents to find solutions to pressing student achievement problems. She also actively involved parents in all facets of school operations, including the Breakfast with Boyer discussion group.

Technology and Technology Support Structure

Computers are available in each classroom for teacher and student use. Each classroom is equipped with at least six Macintosh computers that are connected to a local network and to the Internet. Classes each have educational and multimedia software, and they share access to some technology, such as printers, scanners, and digital cameras. Teachers have desktop computers in the classroom for productivity and instructional uses. Most teachers at the school use e-mail to communicate within the school and with parents.

The school's computer lab is equipped with 30 Macintosh G3 computers connected to a central server and the Internet. One of the computers is connected to a television monitor so that it can be used for teaching. A scanner and a digital printer are also available. The lab is run by a full-time staff member and is booked for use by entire classes, as well as for staff technology training. The distance learning lab provides videoconferencing and closed-circuit television capabilities. Technical support is provided by three technology specialists: The Distance Learning Lab / Video production coordinator, a K-3 Tech specialist, and a 4-6 Tech specialist.

The centerpiece of Mantua's technology use is the One-to-One program in which each fifth- and sixth-grade student is assigned an eMate to use for the full school year, 24 hours a day, 7 days a week. The eMate is a rugged, portable computer designed for use at the elementary school level. The eMate has word processing, e-mail, drawing, spreadsheet, and graphing applications. The display is not a full-size monitor but does allow viewing of several lines of text at one time. Input is by keyboard or stylus, allowing students to switch easily between typing notes and drawing illustrations. There is also an infrared port, allowing teachers to "beam" work to students and students to beam work and messages to each other. In 2001-2002, the program is being expanded and renamed Teaching, Technology and Teamwork (T^3).

Attempts to extend the One to One program to the fourth grade and below have proved difficult because the eMates were purchased with the one-time funds from Texaco (approximately $600,000) and because this low-cost alternative to laptop computers is no longer manufactured by Apple. As a compromise, the school purchased 10 wireless laptop computers that are used by the fourth-grade classes. Although this means that access is more limited, the wireless technology is helpful. The computers can be used all day and then recharged overnight for use again in the morning. The AlphaSmart, a laptop word processor (i.e. not a full computer), is used in K-4 classes.

Mantua teachers have many ways to obtain the training that they need in order to use technology. The school district provides a summer "boot camp" to teach technology basics and courses on using specific software, such as ClarisWorks and PowerPoint. At the school level, the technology specialists provide training for staff who want to make use of the distance learning lab. Computer use and software classes are offered at the school's technology computer lab after school, on weekends, and during the summer. The lab's computer teacher, the school's technology specialists, and staff members with expertise in using a particular piece of software or equipment teach these courses. Staff members with specific expertise also work individually

with teachers who want to learn a new skill. One teacher in the focus group told us how she made use of all these different sorts of opportunities:

> We have little mini-lessons that the computer teacher provides, and she puts the topics out there and if you're interested in going, you can go … and I've utilized that. Also, our distance-learning lab teacher has really supported me in learning how to do things like "Avid-Cinema" and that's just when … when I'm interested something, I can find the expert in the school and fortunately, there are so many people who are an expert in something, even general ed teachers whose main purpose is not technology, they'll be an expert in certain things.

Teachers at Mantua are exposed to a variety of ICT and also to many examples of ICT use from their colleagues. Not only do they observe successful practices, they also recognize practices that they should avoid, as one teacher noted: "We've found a lot of things not to do.…there's always that part of things, well, I won't do that again, that didn't work."

As new teachers join the staff, the process of developing an understanding of the role of technology in instruction is repeated. The process is sometimes easier with younger teachers because they are often already familiar with the technology and perhaps need only to learn how to use it effectively in the classroom.

Although most teachers at Mantua have some professional development in the use of instructional technology, each individual teacher does not need to know how to operate all the school's technology. The technology specialists fulfill a critical role in bridging the type of technology (and sometimes the corresponding nature of the instruction) with the instructional needs of the teacher. To teachers at Mantua, the technology specialist is not just a resource, but also a colleague with whom to plan lessons and coordinate instruction.

For technical problems that cannot be solved at the school level, the district provides technology support specialists who can repair computers, administer the network, and provide other technical assistance.

Context Beyond the School

The Virginia Standards of Learning (SOL) were adopted in the summer of 1995 by the state Board of Education to emphasize the importance of instruction in four core subjects: English, mathematics, science, and history and social science. Satisfaction of SOL becomes a high school graduation requirement in 2004, and all schools must meet accreditation criteria by 2007.

Fairfax County has established Programs of Study (POS) containing curriculum content and essential knowledge and skills for each grade level and course, approved instructional resources; assessment activities, and alignment with the SOL. For the 2000-01 school year, Mantua is one of the 146 (of 194) Fairfax County schools that met the full accreditation criteria of the SOL (an increase of 34 schools from the previous year). Mantua was the seventh-highest-achieving of 132 elementary schools in the district.

Despite Mantua's prominent position among the other county's elementary schools, teachers expressed a variety of opinions about how the Standards of Learning have affected their teaching practices. A second grade teachers explained that she felt the SOLs were too specific for each grade level, hampering their efforts to establish multiage classes that combine two grade levels over a span of two years.

> The children are very comfortable that second year, because there's no transition problem, and you just start off the year…with half a class that you already know, and then they bring in new students who are with you for another two years…so. We haven't gone any higher than third, we tried second and third, but the SOLs won't allow us…to do that because there's just too much curriculum that has to be taught to those third graders…

The Virginia SOL are also incorporated into the Fairfax County school district's professional development offerings. The district's assistant superintendent for technology explained that the Basic School curriculum does not fall outside the SOL and that professional development on the SOL is always available.

> . . .we have aligned what we call our Programs of Study, which is our curriculum, with the standards of learning, and associated with that are software tools, that have helped support. But, you know, our curriculum…we're teaching the Basic curriculum anyway, so it's not like it's a major leak, it's just that, sometimes focusing on some specific areas…we have adjusted our training and we provide training, again, in multiple ways for that…

Improvement in Teaching & Learning

Curriculum and Assessment Aspects of the Improvement

The innovations using technology at Mantua have many components. Below are listed the major innovations, the content areas in which they are used, and the goals or assessments associated with each.

One to One. eMates are used in practically every subject and allow students to work on assignments in school as well as at home. The goals of using eMates, as with all the innovations at Mantua, must be aligned with the content area learning goals. Student assessments on the use of eMates are not conducted because the use of the eMates is not a goal: use of the eMates to improve student learning is.

Wireless Laptop Computers. Since only 10 laptops are available, teachers often combine work in class so that a group of two or three students can work on each laptop. If the class is divided into two groups, the laptops are available to individual students for writing drafts and assignments. The laptops are stored on a movable cart that facilitates transporting them from classroom to classroom. As with the eMates, students are not assessed on their use of the laptops, but rather on the work completed with the laptops.

AlphaSmart. The AlphaSmarts, generally used while at school, allow students to do drafts that can then be downloaded to a desktop computer for further editing or enhancement. AlphaSmarts are used in practically every class, and their purpose is to facilitate student learning within the content areas in which they are used.

Technology Computer Lab. The lab is a schoolwide resource that serves to enhance the curricula and support student instruction. Students research topics on the Internet and complete draft or final reports, either individually or in small groups.

Distance Learning Lab. Each day, sixth-grade students produce an in-house news program called Mantua Morning. Instead of listening to announcements through a public-address system, Mantua students watch as their peers tell of the day's events, with an American Sign Language interpreter simultaneously translating the program for the deaf and hard-of-hearing students. Videoconferences are arranged judiciously, since the cost of the telephone connection is often prohibitive. Like the computer lab, the distance learning lab is a resource to the entire school. Teachers use the lab in conjunction with the content of their lessons and tap resources outside the school that otherwise would not be available.

In addition to standards for Math, History, Science, and English and Writing, the State of Virginia has Standards of Learning (SOL) for instructors of technology as well as for students in 5^{th}, 8^{th}, and 12^{th} grades. Minimum skills that students should acquire by the end of grade 5 include the following:

1. The student will demonstrate a basic understanding of computer theory, including bits, bytes, and binary logic.
2. The student will develop basic technology skills.
3. The student will process, store, retrieve, and transmit electronic information.
4. The student will communicate through application software.

Teachers select the best software available and then use it as a tool to support learning, and not as a means in itself. Teachers are free to choose technology tools that fit with learning goals and to exclude them from their plans when they do not serve learning goals.

The U.S. Department of Education, through the North Central Regional Educational Lab (NCREL), funded a University of Virginia project to work with the Mantua staff on evaluation techniques, including the CBAM (Concerns-Based Adoption Model), especially the "Stages of Concern" component, developed at the Center for Research & Development in Teaching at the University of Texas at Austin. This model was created to encourage teacher buy-in and to propose ways to monitor and increase implementation of educational innovations. Several University of Virginia graduate students have participated in the evaluation activities, particularly the (Comprehensive Interdisciplinary Performance Assessment) CIPA, and in using digital video techniques to record student progress.

Teacher Practices and Outcomes

In following the Basic School philosophy, at Mantua classrooms are grouped around shared open spaces; the open spaces are used for gathering students from all of the classrooms in the grouping, and also as an extension to the individual classrooms to accommodate students working in groups. Mantua has both multiage single grade level classrooms. Class groupings, called "families" at Mantua, occur both by grade and across grades. The technology coordinator explained that these groupings provide for curriculum continuity across those grades.

> . . . In the K-2's they have what are called families…and those families will have kindergarten, first, second grade, various combinations. But it gives that continuum as they plan together and for the students that are involved in those families, then they're familiar with those teachers, they're people who have shared vision within a larger vision. In the summertime we meet as teams to write our curriculum for the year; we look at what the standards are, what the program of studies is, how we combine in the commonalties and philosophies of the Basic School, where we sift in the technology.

Mantua's Comprehensive Interdisciplinary Performance Assessment (CIPA) Program enables staff to determine how well students are performing as a result of implementing the Basic School's Powered by Technology program.

From the beginning, there were indications that the One to One program at Mantua could have an impact on how quickly and how well students understood some concepts. One teacher tells the story of trying to fulfill the district's mandate to do author conferences on student writing. Over the years, she had found that students were not able to critically evaluate writing samples, and therefore the conferences were not effective. She described to us how the first time she tried doing a conference using the eMates, however, she found that they were a perfect tool for scaffolding the students' ability to analyze each other's writing.

> … they were sitting in clusters of four…So, the first author beamed it to the other three kids in their cluster. So, now, when they read it, the kids were reading it on their screens, as they read it…the child read through their whole story and said, okay, we'll read through the whole story first and then come back and have comments. The child finished reading it, and said, okay, so, what do you think? What are the good parts? Everybody said, that was a wonderful story, I loved it, but did you realize that what you read wasn't what you wrote? Wow, so, a REAL comment … about something … for the first time ever, and I'd been trying to do these author conferences for years …now you've got everybody with a story, everybody's scrolling back. Did you realize that paragraph two is one gigantic run-on sentence? Did you realize that you got twenty-seven words spelled wrong? Did you realize that you've use the word 'nice' twelve times in the second paragraph? So, now I've had the author typing in, putting in dialogue, change… right in their story, so they knew where to go back….They were wonderful comments, and that was when I started to see that this could be a wonderful tool for improving writing, the kids are really wonderful at doing that, because they are very good at looking at those things. But, aurally, it's something totally different.

She had a similar experience teaching graphing and the meaning of the slope and intercept. Students opened the graphing calculator on their eMates and entered an equation for a line on the graph. After that line was constructed, the teacher asked the students to enter another equation that would create a second, parallel line on the graph. Then they created a line below the first

line, with its equation generated by the students themselves. From there, they experimented with the slope of the lines, and by the end of the class, they understood not only how to construct a graph, but also the significance of the slope and the intercept. The teacher again was surprised months later, when she was preparing students for the district tests and found that they had retained that understanding of graphs.

Teachers were also enthusiastic about what the Internet added to students' learning experiences. They felt learners had access to many more sources of information on the Internet than they have in their school and local libraries, and that this access changed the way teachers taught topics in history. One teacher explained how invaluable she found primary source materials from the Internet to be while teaching about the Civil War.

> We went to the [civil war] web site of the University of Virginia, and it was wonderful. I divided them in half, you're from the North, you're from the South, and instead of just memorizing facts, it was … but, how did the people feel, you can read their diaries, why did the war start? Don't tell me facts from a book, that's pre-digested information, let's take a look at the primary sources and see how the people at home felt, see what they were reading in the newspapers, why do you think went for this? So, I found out, all of sudden, that it [the Internet] had added a depth to my instruction, and a validity to the information, that they're reading, rather than something somebody's already taken and put into words that kids can understand, so they have to be better readers, they have to be better writers

Mantua teachers are finding multiple ways to make use of the technology facilities that are available. For example, the distance learning lab can be used to let Mantua children share experiences with children in a classroom in another part of the world. A current project has Mantua students participating in discussions with nine schools in Northern Ireland. The lab can also be used for "electronic field trips," where a class of students interacts with staff from a museum or science center or with a topical expert.

This use of the distance learning lab originated when students in a fifth-sixth-grade class started to ask their teacher questions that she could not answer, and she discussed the problem with the school's technology specialists. This specialist had recently learned that it was possible to contact the technology specialist NASA scientists to work with students, so she suggested that they do a videoconference using the facilities in the school's distance learning lab. For both the teacher and the specialist, this conference was a perfect example of the integrated use of technology to support learning. The decision to use videoconferencing was made in the service of learning goals and because it was the appropriate form of technology to use for speaking to a NASA scientist.

The distance learning lab enables students to gather in a video studio at Mantua Elementary School. The videoconferencing system brings the expertise of a NASA scientist to these students, who want to deepen their understanding of black holes. During our site visit, we observed such a conference. Students were seated in rows facing a large screen, where they were able to see the scientist through a camera at his location in Florida. To the right of the screen was a smaller monitor for a second camera at the scientist's location. In the back of the room was a third monitor for the in-studio camera focused on the students. To the left of the large

screen, the teacher stood to moderate the session, with a second in-studio camera focused on her. A parent volunteer was controlling what was displayed on each monitor. When the scientist began to write on his flip chart, the chart appeared on the large screen, and the scientist appeared on the smaller monitor. The students asked questions that they had written, and each was eager to be called on to pose a question. The scientist was clearly impressed by the level of complexity of many of the questions he was asked. His answers were clearly stated, but he did not oversimplify their content. He used the flip chart to show equations and graphs that explained his points. He also showed the students some images and animations of black holes that he thought the students would find exciting. At the end of the conference, everyone agreed that it had been a great learning experience.

Similarly, the computer lab provides teachers with the opportunity to have their students learn research skills while fulfilling individual or group assignments.

Several teachers remarked on how technology resources were valuable because they could be adapted to lessons easily and quickly to support students' interests. This supported their efforts to let the students' interests drive the curriculum under study, as one teacher explained:

> I think the biggest change occurred when I started doing multi-age and we started opening up our curriculum more to what children were interested in…and we could meet the objectives through lessons, but we weren't all the choosing of the curriculum, we were letting them. And we would go off on tangents if they got off on ocean, and we would explore that for a while.

The ease with which materials could be adapted and edited, along with the ubiquitous use of e-mail by teachers in the school, has led to informal professional development and sharing of curriculum, as well as technology assistance support.

> …having the email system that we have, the fact that EVERYONE in the school uses it…all the time, for everything…communication is amazing. I mean, I can put on email, I'm looking to do a project on this, does anyone have anything? Or, you know, I need a book on this…does anyone have a book on this topic? As far as that kind of communication, it's a great tool…it allows us all to know what's going on around the building, and things like that. I also think, because technology is new everyday, I mean, something new comes along, that at some point, there is no one who knows everything. So, everyone here is still learning, and so I think there's a…an idea, where this person knows something this, this person knows something about this topic, this person know Internet, this person…everybody has their skill area, but no one is so much above anyone else, because they don't know everything, because it's always changing. So, that allows for that…that teamwork of, I'll help you, you help me, and we all kind of learn together. . .

Another advantage of Mantua's extensive technology resources is the benefit they can offer preservice teachers. The technology specialist at the school explained how the videoconferencing facilities at Mantua were used to link a master teacher on staff with university educators and cohorts of teacher candidates.

> So, if one cohort is here, the other cohort can be…flies-on-the-wall in that classroom…say if you were teaching a science methods class, while you were talking about science methods you could be watching one of the master teachers here…

Because the use of technology often presents unexpected problems, one teacher said that she always had a backup plan in case the technology-dependent lessons encountered technical difficulties.

Student Practices and Outcomes

We saw students at Mantua engaging in a broad range of technology-related practices. Students used computers for word processing; creating graphs, spreadsheets, and databases; designing multimedia presentations; and accessing the Internet for research.

Students from third through fifth grade have their own computer device to use throughout the school year. Once they have demonstrated competency to their teacher, fifth- and sixth-grade students are issued an Apple eMate laptop to use at home and at school. Third- and fourth-graders have access to AlphaSmart intelligent keyboards and to Macintosh computers in the classroom. At least one computer with Internet access is available in each classroom.

The software to which students have access includes Computer Communication Corporation (CCC) software (classical computer-based instruction), which is available in the computer lab for remediation. Students in grades K-4 have access to a simplified word processor on the AlphaSmarts. This allows students to create draft documents that can then be printed, or downloaded to a computer in the lab for further editing and refinement. In fourth grade, students work in groups with a laptop computer that has a full set of tools for manipulating and interpreting data in tables, charts, and graphs. The eMate computers have word processing, e-mail, drawing, spreadsheet, and graphing applications. Every Friday, students summarize their week through "mandatory e-mail" that is either printed or e-mailed to their parents.

One student commented on the differences between writing a paper and doing a slide presentation in a program such as PowerPoint. He said the slide show format requires students to go beyond presenting facts to thinking about audience and the effectiveness of different media, such as text and photographs, for communicating.

> I think it's a little tougher to do a slide show, because with a paper, you've got the facts, you can kind of get them down, but when you're making a slide show, people don't just want to see text. You want to have effects, you can insert pictures, and the teachers expect when you choose something like to use a computer, they expect above and beyond what you'd do by hand, because they do expect you to take full advantage of the technology that you have. And, it's kind of difficult to do really good slide show, because you have to consider … am I getting information across? Can people read this? Are people interested? You know, are there good pictures, there's a number of different things to consider, and if you are good at that, and you get it done, it can be spectacular and a hundred times better than a … than just a written paper, but it is more difficult and there's a number of different things you have to consider.

Another student said that the use of technology prompted teachers to have higher standards for students' work because of their access to additional resources. When students use school

libraries, they typically use secondary sources such as textbooks and encyclopedias. In addition, there may be a limited number of books on a given topic, so that each student may not have equal access to the best resources.

> I mean, if you have to go to the library and get a bunch of books … the standards, the teachers can't set very high. But, now, I mean, you have all this information [on the Internet] that you can access, so, the standards are higher. And, that was hard at first, but you learn it and then it's, it's a great tool.

One student described the difference between another school without advanced technology and Mantua as the difference between students covering topics in a rote fashion and covering topics in a way that spurs them to become lifelong learners.

> But, they're [students at the other school] covering the same stuff, but they're probably not enjoying it as much, it's just kind of, it's memorization of facts and it's … learning can much more interesting when … if you have computers, and I'm sure he's covering the same things and does … and their school does well on the SOL's and any other test, it's just a matter of… are kids wanting to learning, is this going to form a habit of lifelong learning and … and teaching them how to use technology, that's schooling that's going to be useful later in life, and I think that any school can benefit from technology, because that is something that definitely really helps learning and makes it … even though you learn the same things in the end, usually, it just makes it so much better. [S307]

The videoconferencing system in the distance learning lab has provided benefits to students. The general student population has been involved in conferences with their peers from around the world and with experts, such as the conference with the NASA scientist described in a previous section. Deaf students have also participated in conferences with other schools for the deaf from around the country. Because the incidence rate of deafness is low for young students, this connection is important for expanding the population of peers of Mantua's deaf and hard-of-hearing students.

Parents say that technology use has benefited their children. In a focus group, one parent explained the change that resulted in her child's approach to academic work:

> … the most beneficial thing for her, I think, was it made more independent in her schoolwork when she got home. Because she could come home and she knew how to use that email, and she knew what she had to do and she would sit down and do it. And before, she didn't use the computer all that often, or when she did, she needed a lot of help, so it really did make her independent and made the homework so much easier on the family. And it also helped my son, who had a terrible time writing…I mean, he didn't, he was academically very strong, but when it came to actually physically taking a pencil, or a pen, and writing, for him was…absolute torture, so…and his goal in life was always to use the least amount of words possible to say exactly what you wanted to say …and it wasn't until he got the e-Mate when he started writing, I mean, it wasn't painful anymore. That was night and day, it was unbelievable.

Another parent with a dyslexic son said that the eMate has helped him to keep his train of thought when he is writing, and consequently, to write more. The eMate helps him to do this because he knows he can review his work with the spell check tool, so he finishes writing the content before correcting his spelling errors.

Mantua students perform well on standardized tests. Scores on the Stanford Achievement Test in all subject areas tested in 1999-2000 are above the 70th national percentile equivalent. For example, sixth-grade students scored at the 79th percentile for language, the 84th percentile for science, and the 88th percentile for reading. While the standardized test scores show that the educational achievement of Mantua students compares favorably to the achievement of students across the country, these results do not establish the impact of technology on student achievement. Although there have been attempts, the school has not yet been able to gather data showing that technology is helping students learn. The principal noted that from the beginning of technology use, they knew that they needed to measure outcomes, but they could not identify a way to separate the impact of technology from other factors.

> We started trying to work on an evaluation. And, very quickly, in that first year we realized, well we spent a lot of time in that first year trying to prove that technology made a difference. We made surveys, we gathered data, we thought we really thought we had it handled, we thought by the end of the year this is going to be great. Well, by the end of first year, we realized that you can't separate the technology from the curriculum, and that the only thing that we really proved, in quantifiable ways was that our children improved their typing speed; we're very good at doing that.

For the past 2 years, sixth-grade students have participated in an experimental multiple-assessment program called CIPA (Comprehensive Interdisciplinary Performance Assessment). Although there is no explicit requirement for students to use technology within their CIPA project, the extent to which students show their mastery of technology in the production of their CIPA material is a powerful indicator.

Lessons for the Future

Noteworthy Outcomes

With all that they have pioneered, educators from Mantua are frequently called on to make presentations about the school, and they disseminate what they have learned in this and other ways. The staff, students, and parents are very proud of the school and its leadership role, and are also very appreciative of being a part of a school with a strong vision and a history of achievement.

In the case of students in the Total Communications Center for the Deaf, technology is helping them to understand language. Students at the Center come from all over Fairfax County, as well as from other counties, and they reflect the economic and cultural diversity of Fairfax and surrounding counties. Technology has had a significant impact on their progress. Mantua's current principal, formerly a teacher in the Center, described the first two years of technology use in the classrooms of deaf students as astonishing. The visual accessibility that was set up by having the technology allowed for constant comparison between English print and American Sign Language supported literacy improvement.

Added Value from technology

The added value from technology is evident from the variety of student and teacher practices that have changed or that would not have been possible without the technology resources to successfully support them and integrate them into instruction. A significant change for teachers as a result of their use of technology is their skill and comfort level in developing and executing lesson plans that use technology extensively.

For students, use of ICT such as e-Mates has helped them develop good typing skills. The e-Mates' beaming feature brought unexpected advantages during instruction. Students could easily share work or teachers' notes using the e-Mate infrared port. The e-Mates' capacity to beam information was also used to improve student writing and to help students pay attention to aurally transmitted information by also providing the information visually.

Some teachers commented on the empowering effect that their students and they felt when they discovered some of the rich source material available on the Internet, and discussed how that discovery has shaped their views on what they would like in the future.

The added value of the distance learning lab is that it performs functions in support of learning for students with disabilities. The lab was built with funding from Bell Atlantic, and an important goal for the lab from the beginning was to provide visual access to the deaf and hard-of-hearing students. Both hearing and deaf students are able to share in the morning announcements through the visual medium of television because the news program is also signed as well as spoken.

Key Implementation Factors

The decision to have a technology focus at Mantua evolved from planning discussions the school staff undertook in order to obtain settlement funds from Texaco, which were to be used for technology. While the school leaders made commitments to using technology in specified ways, individual teachers differed in how prepared they felt to use technology in their own classrooms. At the time of our visit, the uses of technology varied by staff member. The technology leaders at Mantua Elementary have learned that the process of integrating technology into instruction is individual, and not all teachers are eager to use technology. Rather than insisting that each teacher use technology in a specified way, there is a concerted effort to help teachers progress at their own rate; over time, most teachers have found that they can make effective use of technology for some of their instruction.

The school's commitment to one-to-one access remains strong, despite the immense challenge of funding the replacement of the eMates and of extending one-to-one computer access to more students. The district does provide financial support for the use of technology, and Mantua's PTA is able to raise large sums of money, but continued funding for the One to One program will not be achieved without the support of business partners. The technology committee is currently meeting with prospective business partners to ensure the continuation of the One to One program.

Mantua is also working on an initiative called the Central pyramid. The pyramid includes Mantua, four other elementary schools, and the middle and high schools the elementary students will attend. The goal of the pyramid is to take the model of technology use developed at Mantua and implement it at each of the other schools in the pyramid. To date, Mantua's use of technology has involved K-6 students, but by spreading the model to the other schools, the impact of the model through 12th grade could be observed. The Fairfax School District is willing to provide some financial support to the Central pyramid because it will serve as a pilot for the district. Beyond funding from the district and from the schools themselves, Mantua's principal says they are negotiating with a couple of companies to act as pilot sites for K-12 use of their computers and other technology.

Challenges

Although technology use at Mantua has reached a stable level, there are concerns about how the school will maintain and expand its One to One program. Staff, students, and parents are great supporters of the eMate and cite only two drawbacks: the vintage of eMate at Mantua cannot be used for Internet browsing, and student use of the keyboard may hamper the development of their cursive writing. There are no plans to abandon the vision of one-to-one computer access for at least the upper grades at the school. Since the Apple eMate is no longer being produced, Mantua has entered into a partnership with Hewlett-Packard that will equip a sixth-grade class with HP Jornada devices (with keyboards). Students recognize that they have benefited from the special capabilities available at Mantua and are concerned that they will not have those facilities when they move up to their next school.

Another challenge was handling the transition to a technology school and ensuring that teacher turnover did not derail efforts to proliferate a common vision among teachers. Although teacher turnover was higher than usual during the school year in which this case study site visit was conducted, the principal attributed most of the departures to marriages, retirements, and spousal relocations. She also recalled her predecessor's ultimatum to teachers, an effort to maintain a shared vision among staff who did not fully buy into the technology reforms:

> There have been times when our former principal. . . said to a couple of people, this is what we're doing here, and if you not on this bandwagon, if you're not walking down this path with us, if you don't share this vision, then maybe Mantua is not the best place for you, and I will help you find another school. Now, I think in reality, over four years, I can think of two people for whom that was truly the reason why they left.

The problem of buy-in is becoming less of an issue as new teachers arrive at the school in part because new teachers have had more exposure to technology. A fifth-grade teacher elaborated on the extensive use of technology in her preservice preparation, which continued through professional development opportunities when she arrived at Mantua.

> I'm young enough that I've had a computer all of my life, in my home, so I was very comfortable walking it, and then…well, I just finished graduate school three years ago, before I got here…so, I had taken several graphic courses in technology, as part of the requirement for my graduate degree in education. So, I took classes on building webpages and everything like that…so I came into Mantua with a lot of background knowledge of how to teach with technology. And then, since I've been here,…I have. . .

> taken classes through the county, one of them was building a webpage using specific software. And then, in terms of what I do in the school, we…the one-to-one team, which is our e-mate team…we have training sessions continually, 'cause we always get new teachers in and there's always refresher course.

Finally, the major challenge of securing funding for computers and upgrades can no longer depend on an oil company's settlement. A district administrator shared her thoughts about how to overcome this challenge.

> Technology refreshment is a challenge for us; in the last few years we have moved to almost of our new computer purchases are on a lease-basis. So you get to an automatic, in our case, five-year refreshment cycle. We also are looking more and more at business partnerships, and you'll see here, there's quite a number of business partners and looking at even more than that…to help sustain and expand the technology. In the county, we tend to emphasize the central money on things like infrastructure and personnel, and try to get additional resources and alternative resources for the end-user equipment, you know, whether they be business partners or…PTA's…So, it's sort of that we're all in a partnership; it takes all of those pieces together to make it work.

Appendix A – Supplemental Information

The Basic School Network

The Basic School Network was established in 1994 by Ernest L. Boyer, President of the Carnegie Foundation for the Advancement of Teaching. The Network began as a 12-school demonstration project engaged with the four priorities for school excellence identified by Boyer in The Basic School: A Community for Learning. The Ewing Marion Kauffman Foundation, based in Kansas City, Missouri, is the primary funder of the National Basic School Network. The National Association of Elementary School Principals (NAESP), Teaching PreK-8 Magazine (TK-8), Association for Supervision and Curriculum Development (ASCD), Developmental Studies Center (DSC), and National Reading Styles Institute are affiliate organizations of the Network.

The Basic School National Center is housed at the National Center for Restructuring Education, Schools, and Teaching (NCREST) at the University of Missouri. Today, the National Network numbers more than 125 members, and there are regional service centers in Iowa, Kansas City, Oregon, Texas, and Virginia. Each serves schools in and around its home state with a variety of services to help create learning communities where academic excellence and civic and personal responsibility are nurtured. (See http://basicschool.coe.missouri.edu/index.htm)

Mantua is served by the Basic School Eastern Consortia, a Network center based at James Madison University (JMU). The Consortia is part of JMU's Research and Program Innovation Department and is housed in the Chancellor's Office. Schools in Connecticut, New Jersey, New York, West Virginia, Virginia, North Carolina, Georgia, Florida, Louisiana, Tennessee, Kentucky, Ohio, and Indiana are currently served by the Eastern Consortia.

Total Communication Program for Deaf Students

The mission of the Total Communication Program is to meet the educational needs of deaf students in a safe learning environment that stimulates the acquisition and communication of knowledge in the least restrictive environment.

Total Communication is a means to convey language, vocabulary, and concepts through speech, reading, amplification, fingerspelling, and sign language.

Teachers of the deaf use the Fairfax County Program of Studies (POS) as a curriculum guide. The Supplemental Language Curriculum, specifically designed for the language development of the deaf, is used in conjunction with the Fairfax County POS.

Educational services are provided to 73 students from birth through 12th grade. The teacher works in the home with children under the age of 2 as well as with their parents. Children from 2 years through sixth grade attend Mantua Elementary and then move on to intermediate, high school, and vocational sites throughout the county.

[SOURCE: Mantua Web Site: http://www.fcps.edu/MantuaES/totalcom/totalcom.htm]

About the Concerns-Based Adoption Model

Gene Hall, Shirley Hord, Susan Loucks-Horsley, and Leslie Huling, all members of the original research and development team for the CBAM, continue to be prime movers in teacher education and staff development today.

One of the best sources of information on this model and its uses is:

Shirley Hord, William L. Rutherford, Leslie Huling-Austin, et. al. (1987). *Taking charge of change*. Alexandria, Virginia: Association for Supervision and Curriculum Development.

Comprehensive Interdisciplinary Performance Assessment

Mantua has begun using multiple assessments, particularly performance-based assessments. According to the principal, the school was concerned that the state's Standards of Learning (SOL) test would become the only measure of a student's performance, and it wanted other ways to show what the students were learning.

Before deciding what types of multiple assessments to use, the school asked the business community what skills children will need to succeed. "They [the business community] said they could teach employees the computer and program skills they will need. But what they can't teach is how to approach a problem, how to work together on a team, how to access information, and how to present that information," said the principal.

Armed with that knowledge, the school went back and developed the Comprehensive Interdisciplinary Performance Assessment (CIPA). This 2 week program places sixth-graders in groups of four to six, gives them a real-world problem, and asks them to research, prepare, and present a solution to a three-teacher panel.

This program not only tells the school how and what the students are learning, it also shows whether the school's instructional program is meeting the needs of the children.

Since the CIPA is designed to be a culmination of a group process and product learning, and not a test of individual knowledge, students do not receive grades. There is, however, sufficient feedback. Throughout the process, students keep records on what they have worked on, and each day the students are expected to complete a rubric. At the end of the process, a rubric is completed by each of the panel members, and a conference is scheduled with each student.

"It would be nice to continue to pass the SOLs," said the principal. "But what we are doing with this program is more critical to the children's success. You have to teach children how to think, not just how to memorize and regurgitate facts."

[SOURCE: NAESP (2000). Multiple assessments: One size does not fit all. http://www.naesp.org/comm/c0900.htm]