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# BUSINESS @ THE SPEED OF THOUGHT

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## USING A DIGITAL NERVOUS SYSTEM

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## CREATE CONNECTED LEARNING COMMUNITIES

Our national commitment to connect every classroom in every school in the country to the Internet will be the greatest advance in quality and equality of education in this century.

—Reed Hundt, Chairman of the U.S. Federal Communications Commission

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PCs can empower teachers and students more than any other group of knowledge workers. As I mentioned in describing the Web lifestyle, students are the ultimate "knowledge workers" since learning is all about acquiring knowledge. Teachers will be able to use the Internet to share with each other and to allow students to explore a subject in new ways. PCs can be a catalyst for reaching the educational goals that parents, educators, and government have set forth, such as collaborative learning, critical thinking, and lifelong learning skills. With a solid infrastructure in place, some schools are already benefiting from incorporating PCs in the classroom. Even as most schools struggle to find the resources for these new tools,

innovative programs have shown that there is a payoff for the effort.

The success of PCs as educational tools requires teacher involvement. Without teacher training and integration into the curriculum, PCs will not have a big impact. Many PCs have gone into computer "labs" where they sit, seldom used. Schools need to shift from treating the PC as a subject unto itself—teaching about technology—to integrating the PC throughout the curriculum, teaching with technology. More and more school districts are now demonstrating that with the involvement of teachers, PCs used as learning tools can have a profound effect.

In the Western Heights Independent School District, just west of Oklahoma City, Oklahoma, teachers surprised administrators with their enthusiasm when the district provided training the summer before it rolled out PCs. More than 200 of its 230 teachers signed up, causing the district to scramble to schedule enough sessions to handle the demand. Most teachers have a great love of learning, and they'll get excited about anything that will help kids learn. What teachers don't want is to be thrown into something they have not had the opportunity to learn about and become comfortable with.

Western Heights is a small, seven-school district with a moderate industrial tax base. The student population is a multicultural mix of white, black, Native American, Hispanic, and Asian descent. About 65 percent of the kids qualify for free or reduced-cost lunches in the school lunch program. This is not the school district that you might expect to lead the charge into the Information Age. Yet in the last three years the district has overwhelmingly voted three times to spend a total of more than \$6.8 million in local funds to create perhaps the leading technology-driven curriculum in the country. The community sees the investi-

ment as the only way to break the cycle of poverty that could repeat with its children if they go unprepared into the digital world.

A PC can be a powerful new teaching tool for teachers coming from the world of blackboards and chalk. Using PowerPoint, for instance, teachers find they can spark kids' interest in the subject by including photos, film clips, and links to Internet pages. One civics teacher at Western Heights starts his class each day with fresh news from the Internet. First is a science photo of the day from a NASA Web page; then news clips from abcnews.com; then a story that leads into his curriculum topic, which could be campaign-finance reform or government checks and balances.

PCs are part of each teacher's life in class at Western Heights, not something outside. Teachers use e-mail to communicate with one another about common issues. They don't have to wait for the district meetings that occur a couple of times a year. They can reach out to a colleague with a question and get an answer back quickly. This collaboration occurs among teachers in each grade level or among teachers coordinating curricula across grade levels, in disciplines such as science, math, and language. Computers are allowing teachers to more easily reach out beyond the confines of their classrooms and interact with their peers.

"People may not realize how alone teachers are in the classroom," Western Heights superintendent Joe Kitchens says. "Most teachers remain behind closed doors all day. They have little time for sharing experiences or interacting with other teachers. There are only a few times a year when they can gather with their peers. E-mail eliminates that isolation." Kitchens laughingly complains that teachers are able to "bug him" more than before, too. Traditionally, the superintendent would have limited dialogue with teach-

ers. Now they expect him to answer their questions immediately over e-mail.

Western Heights' PC-based network runs on seventeen miles of fiber-optic cable among the schools and administration building. Each of the 230 classrooms has at least two PCs on the network—one for the teacher, the other for kids to use. Each room is wired for another three PCs to be on the network, and each school has a computer lab. A huge monitor in each classroom enables teachers to display material off the Internet, or films from a central video server, or presentations from another classroom.

University of Oklahoma instructors have taught classes remotely. The meteorologist from the local TV station has taught classes about tornadoes and other weather topics, and students have broadcast weather reports back for public broadcast. Dayton Tire, the area's major employer, has participated in videoconference sessions on topics such as job-interviewing skills and chemical engineering. The TV station and the local tire plant were included in the district's fiber-optic system for just this kind of community involvement in teaching. The university connects through Oklahoma's high-speed education network.

Students have used the videoconferencing system to take virtual field trips to the East Coast, to England, and to other places in Europe, visiting museums and studying with sister schools. Students throughout the district watched the space shuttle launch with John Glenn in late 1998 live over their PCs. Several classrooms are set up specifically for distance learning via PC-based TV. These setups have enabled Western Heights to add advanced math classes in its middle school by TV instruction from the high school. It's not a perfect solution, but it's better than no advanced math class. Teachers have benefited from a videoconference course through the University of Kansas

to help them enhance class content and curriculum with new technologies.

Distance learning has also enabled students at home with injury or illness to keep up with their classes. One teenager was home for months with injuries he sustained protecting his mother from a gunman. Previously the school would have sent out a "home teacher" three times a week for an hour a day. The home teacher would pick up homework, hand off more assignments, and answer a few questions. This time around, Western Heights put a PC, camera, and monitor in the student's bedroom and set up a high-speed link to his home.

Not knowing how well the interactive link was going to work, the school began by connecting him with only one class, but his classmates complained loudly when he "wasn't there" at their next class. The school immediately extended the televised sessions to include all his courses. Biology class was probably the most interesting for him, since the other kids were always sure to hold the really gross dissections up close to the camera, play similar pranks, and otherwise make him feel like part of the group. This home-PC link was cheaper than a home teacher, and the student learned far more. He kept up with his work and grades, but more important, he was never lost as a member of the class. In another instance, a teacher helped direct the work of substitute teachers and stay in touch with her students while she was home because of medical treatments.

#### CONNECTING WITH PARENTS AND THE COMMUNITY

Another school making similar investments in the future is Reading's Highdown School, a publicly funded state school in a town of 140,000 people west of London. Highdown is

in the heart of the U.K.'s Silicon Valley. A large number of the country's high-tech firms are located within twenty miles. Highdown's proposal to create a connected learning community became one of twenty-three trials accepted as part of the country's digital Superhighways Initiative.

Highdown decided to make technology a central part of the educational experience: to connect the entire community with the school, including museums, libraries, and government offices. Educators wanted a sustainable model so that the approach would not fall by the wayside after the initial enthusiasm waned. They wanted to raise educational performance standards and motivate lifelong learning.

Highdown's network connects more than a hundred PCs in the school with interactive CDs and filtered content from the Internet. As Highdown moves from trial to a long-term program, the local council has joined in to help expand the network to all forty-six schools in the borough. Students have individual computer accounts so they can access productivity applications, e-mail, and the Internet from home.

Parental involvement has been instrumental in the success of the program. Thirty parents participated in the initial development and were able to routinely log in from home to check the school's intranet and find out about their children's activities. Another thirty teachers are connected at home. The school is about to extend the opportunity to link from home to all its parents and is adapting learning materials to allow student learning to be supported at home. Highdown's intranet home page has information on the school and on the subject being taught. The Web site shows parents what students are supposed to learn each week and the approach teachers are using. Parents can link to the materials used by the students. The Internet solves the age-old problem of parents asking their children

whether they have any homework and being unable to verify the answer when the children invariably say, "No." Parents also have immediate access to teachers via e-mail, in addition to personal meetings several times a year.

Like Western Heights, Highdown is integrating technology into the classroom. Its Web page provides special curriculum features that would otherwise not be possible, such as a virtual art tour that links to important museums around the world. Technology makes it easy for teachers to scale classes to age and ability and individualize learning. An eleven-year-old art student, for instance, can go online to access age-appropriate materials prepared by the teacher to support the concepts presented in class on the theory of color. An online test measures understanding of complementary colors, and the student can link to artwork by Seurat to show how he used the eye's perception of colors to create pleasing visual effects.

An independent review of the Highdown experiment by government researchers listed six major benefits of technology-based instruction. These were improved subject learning; improved "network" literacy, meaning skills in using PCs and the Internet to learn; improved vocational training; better motivation and attitudes toward learning; improved skills in independent learning and research; and better social development.

#### LINKING THE SKILLS OF ALL CHILDRN

Using the school infrastructure to support education for the entire community is an important way to take advantage of—and to justify—technology investments. One type of education is basic literacy skills in computers that can be applied at any job. Another type, with great potential for

people seeking employment, is training in information technology itself. In most countries, one out of every ten IT jobs is going unfilled, with the United States and Europe each needing more than half a million new trained IT professionals in the next several years. Rapidly developing areas such as India and Latin America may have proportionately greater shortages.

Because the prosperity of the Reading area is based on technology and because traditional funding sources for schools are unlikely to be sufficient for its plans, Highdown School envisions a public-private partnership to pay for needed infrastructure, an "investment loop" whereby the business community invests in schools today and receives, down the road, more highly trained workers.

Also, because the community will use the network for long-term education, Highdown educators expect the community to contribute. Adults can get online technical training either at the Reading schools, which open on evenings and weekends for that purpose, or at home. Fees for this service go toward maintaining and expanding the IT system.

Many schools around the world are moving rapidly to prepare for the digital age. Israel has a national education network that lets students gather knowledge and use e-mail either at school or from home. The network improves parent-teacher interaction. Costa Rica is providing every public high school student with access to the Internet and e-mail. High school students in Issaquah, Washington, in the United States planned, built, and manage a district network of 2,000 PCs used to teach advanced academic skills. Students in Kentucky are also being trained to support their network, which spans the entire state—176 districts—and includes connections with the state government and, eventually, local businesses and higher education.

#### ARMING EVERY STUDENT FOR SUCCESS

Most knowledgeable workers in the United States have their own PC, yet even at the best of schools the ratio is often no better than seven students to every PC. It's expensive for schools to buy PCs for every student, especially when PCs become out-of-date every three years or so. For this reason there's a fear that the gap between the "haves"—those families that can afford PCs at home—and the "have-nots"—those that cannot afford PCs at home—will create a major gap in opportunities. Creative approaches in providing PCs to every student show great promise in helping resolve this dilemma.

One-to-one access—one PC per student—started in the early 1990s in Melbourne, Australia, where Bruce Dixon, a teacher interested in technology, saw significant differences in teaching results when he could scrounge a half dozen computers for his classes instead of just one. For PCs to achieve their full potential, he realized, students had to use them as a tool for all their work—in all their classes and at home as well as at school. Out of many discussions, conferences, and brainstorming with teaching colleagues emerged the radical idea of having all the students finance their own machines. Dixon, by then a technology consultant to schools, worked out a financial model. For a monthly fee, students lease a machine and software; the vendor provides maintenance and upgrades; and when the student graduates the family keeps the machine.

Affordability is still a big challenge with this approach. Families that are well-off can afford the typical \$40 monthly fee over a three-year period. Many families can afford to pay some modest amount, if not the full fee. Business, community organizations, and grants can make up the difference for the rest of the kids. Regardless of the

amount, the family contribution is fundamental to this program, as it gives the student and their parents a sense of ownership of and responsibility for the laptop and its role in the student's learning. In the first several years of laptop programs, damage, loss, or theft of the PCs has been minimal. Educators say the reason is that students have a vested interest in taking good care of their machines. Interestingly, students from underprivileged neighborhoods generally have less loss or damage than do students from rich schools. The only consistent problem with damage has stemmed from students closing laptops with pens or pencils inside. This habit, a carryover from books, cracks the screen. Students are now warned up front about the danger posed by writing instruments.

Laptop programs have spread to schools worldwide. More than 60,000 students and teachers at 500 public and private schools in the United States have participated in the Anytime Anywhere Learning laptop program. The initial sponsor was Toshiba America Information Systems, and many more hardware manufacturers are involved today. This program brings laptops to students, trains teachers in their use, and integrates technology into curriculum. Large-scale programs have succeeded with 500 students in Harlem; 1,500 students in Beaufort County School District, South Carolina; 1,200 students in the Clovis Unified School District, Fresno County, California; and 500 students in the Federal Way School District in Washington State, to name just a few. By working with local businesses and the community, these schools have been able to finance laptops for all students. Both Canada and the United Kingdom have begun piloting laptop programs, and educational delegations from around the world have visited Anytime Anywhere Learning schools to evaluate their use.

The impact of providing laptops for full-time use by

students has been impressive. A recent study titled "Powerful Tools for Schooling: Second Year Study of the Laptop Program" by education researcher Saul Rockman concludes that students who regularly use laptops gain many skills. They write more often and better; have improved research and analysis skills; express themselves more creatively; work more independently and also more collaboratively; more frequently rely on active learning and study strategies; readily engage in problem solving and critical thinking; and adopt higher-order thinking skills. Objective numbers in the study are supported by the subjective reactions by teachers: 66 percent said laptops increased higher-order thinking by their students, and 71 percent said laptops improved student motivation and made students more willing to focus on schoolwork.

Most school systems around the world are just beginning to bring PCs into the classroom. To get started requires leadership at the school board and superintendent level and a technology plan that provides a blueprint for developing and managing the technical infrastructure, for integrating technology with curriculum, and for training teachers. Finally, rallying community support is critical. Voters have proven willing to vote for measures to fund concrete, well-fashioned plans. Communities should think of connecting the schools as the start of a broader effort to create a connected learning community among all civic organizations and to think of technology-enhanced education as a lifelong activity not restricted by age or to schools. Technology can also reduce administrative overhead in schools and make it easier to compare educational results. The state of Victoria in Australia has deployed an infrastructure that will eventually connect 100,000 PCs, providing a 5-to-1 ratio of students to PCs across the state; Victoria is training every principal and teacher from all

## PCs for Every Student Make a Big Difference

Michael's transition from elementary school to middle school at New York City's Mott Hall School was difficult. The challenging coursework and more competitive environment caused him to withdraw. Michael's teacher, Janice Gordon, believed that the school's Anytime Anywhere Learning program, which offered a laptop to every student, would help him overcome the problems with his handwriting and disorganization and give him more confidence.

She was right. Within two months of getting his own laptop PC, Michael was participating in discussions and sharing his work with the entire class. He does extra homework and in-depth research for class projects. His dad calls him "the Michael Jordan of the computer world."

I visited Ms. Gordon's class in the spring of 1998 and saw firsthand how the constant availability of a laptop PC was changing learning for Michael and his classmates. His newfound success is not an isolated result. In more than 500 public and private schools, kids are using laptops to exercise their curiosity and creativity in ways that perhaps only kids can.

A history student used an online encyclopedia and Web sites to create a presentation on the U.S. Civil War covering famous generals and important battles, including statistics and maps. A science student used the Internet to produce a report on how wax improves speed and reduces friction for snowboards and how boots and bindings provide stability. Foreign-language students go to Spanish-language Web sites so they can better understand how the language is used every day.

PCs also provide new ways to approach traditional studies. Fifth- and sixth-grade students created their own database of the planets, gathered data from several sources, used an online encyclopedia to embed pictures, and wrote a paper about what they had learned. High school students took data on the motion of a cart with different forces and masses applied to it and used a spreadsheet to graphically see the changes so they could visualize the mathematical relationship among force, mass, and acceleration.

Laptops also make it possible for teachers to create more comprehensive projects. In an Ohio history class, a "Destination Ohio" project had students use the Internet for research on sites to see in Ohio, a word processor to plan an itinerary of their trip, a spreadsheet to track costs, publishing software to make a brochure for one of their destinations, and presentation software to "sell" this trip to other students.

The depth and breadth of information that comes from access to technology and the ease in analyzing data are improving fundamental skills such as writing ability and analytical ability. By seeing and examining more information from more points of view, students become better aware of viewing sources critically and making independent judgments.

1,750 schools on the integration of technology into schoolwork. Victoria is also employing PCs to handle business processes—for example, using e-mail to disseminate school documents and memos, financial statements, and images to its many remote schools. Administrators will use software to track trends in student absences, which might reveal educational problems, or staff absences, which might reveal morale problems. Administrators plan to use digital tools to easily compare and contrast everything including testing results by region, grade level, or school size. They want to provide more software support for teachers, whether administrative (managing attendance or generating standard letters to parents) or professional (student skill assessment). At Western Heights in the United States, teachers use an application that scans in test papers, grades them, and automatically reaverages the kids' grades. The time saved can now be spent on teaching.

### OFFERING A VARIETY OF WAYS TO LEARN

One of the most forward-looking ideas is to use PCs to offer a variety of ways to learn. About fifty different major theories attempt to characterize individual learning styles. Most of the theories identify similar attributes. In the simplest terms, some people learn better by reading, some by listening, some by watching someone else do a task, some by doing the task. Most of us learn from some combination of all these methods. And all people have different levels of aptitude and different personalities and life experiences that may motivate them to learn or demotivate them. A highly motivated student can learn from difficult reading materials, where a poorly motivated student needs accessible materials such as a video to learn.

New software is helping students learn regardless of learning style or pace. Software can present information in multiple forms that can be personalized far more easily than paper methods. In teaching geography to twelve- and thirteen-year-olds, for instance, Highdown School previously relied on videos of Mount St. Helens and a large stack of printed materials. Some kids did well with these resources; others, less motivated, got bogged down in the dense text.

With Web technology the school now structures a series of learning tasks according to complexity. Students are required to complete a certain amount of work to ensure they understand the concept. The first geology task incorporates multimedia animation of moving magma to help every student understand the basics of volcano formation. The most advanced task is an in-depth survey of volcanoes that includes links to the U.S. Geologic Survey Web site. Students who want to explore further—and many do—can drill into great detail on a number of active volcanoes and their effect on nearby towns and the world's environment.

PCs can help change the learning experience from the traditional approach—a teacher talking at the front of the classroom, coupled with reading assignments—to a more hands-on approach that takes advantage of the natural curiosity of students of all ages. PCs enable students to explore information at their own pace, to learn from video and audio as well as from text, to model experiments, and to collaborate with one another.

This self-directed problem-solving approach, usually described as progressive, is not new. John Dewey and other educational reformers were proposing a change from didactic to experiential learning in 1899. But where building a physical facility to give kids a wide range of experience is complex, a virtual world of experiences on computers is available to all connected students.

Web connectivity builds on the PC's capabilities by enabling students to find other people who are exploring the same topics or to find approaches to a subject that might be more helpful or interesting to them than the approach used in class. They may find a nugget of information that they enjoy bringing back to the class, or one that confused them and the teacher can address for the benefit of everybody. A common assignment will be for students to go out and explore a topic on the Internet, then come back together in a group to discuss what they learned.

The great lectures on all important subjects will become widely available on the Internet. Schools will be able to use them as the core presentations, creating study groups and discussion groups around the topics. Schools will vary in how much they take advantage of these lectures. Local teachers will be freed to develop more in-depth material and personalized instruction rather than duplicating the core lectures, as they have to do today.

### Steps to Integrate PCs in the Classroom



**Step 1**  
Establish infrastructure and train teachers and pupils

**Step 2**  
Use PCs to improve existing models of teaching/learning

**Step 3**  
Use PCs to transform modes of teaching/learning

YOU ARE HERE

School districts need to have a plan to use PCs to improve education. The first step is to enlist community support, establish a solid technical infrastructure, and train teachers. Next, PCs and the Internet should be integrated into the curriculum, with PCs serving as a learning tool for students. Finally, digital methods can transform learning by making it easier to create and maintain core presentations, freeing teachers to create more in-depth material and personalized instruction.

## Ten Hard Lessons on Computers in Schools

**M**ore than a decade of use shows that computers can help educate students, but society has learned ten hard lessons along the way. I concur with the conclusions of a November 1997 special report by *The Wall Street Journal*:

1. Computer labs are a lousy place for computers. They need to be in classrooms.
2. Struggling students often get more out of computers than higher performers.
3. Most teachers still haven't been trained on how to use computers in class.
4. School systems must plan computer use carefully.
5. Computers are a tool, not a subject. They need to be integrated into the lessons of other subjects.
6. Kids flourish when everyone has a computer.
7. Hand-me-down machines are not good enough for school use.
8. Computers don't diminish traditional skills.
9. The Internet and e-mail excite kids by giving them an audience.
10. Kids love computers.

Once we have a critical mass of teachers sharing ideas electronically and a higher and higher percentage of the students with access to the PC, the textbook industry will make a fundamental shift to focus on electronic delivery of products. Having textbooks available electronically at lower cost will enable cash-strapped schools to redirect money spent on printed textbooks for other needs. In 1997 elementary schools in the United States spent \$3 billion on physical books. College spending was another \$2.7 billion. Yet a typical CD can hold all of the reading materials a student needs in a year, with online connections providing the additional breadth and depth. Use of PCs as a primary reading tool will require the breakthrough in screen readability discussed in chapters 3 and 7.

PCs are the primary communications and productivity tools of the digital age. The PC and the Internet fundamentally change one thing: They provide every student in every school and community with access to information and collaboration that before now was not available even to students in the best schools. Educators will take advantage of that access for the betterment of their communities. Educators who embrace PCs as a new teaching and learning tool will be the agents of change.