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The Whole World in Their Hands

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Information technologies have the potential to make huge improvements in education over the next decade as they reshape society and create new learning opportunities. Whether this potential will be realized for all students depends critically on the ability of education to reinvent itself at the local level. In this paper, I will briefly examine the impact of networking on learning in general and science education in particular. Then I will ask how these new resources will influence the educational system and its ability to reach all students.

Writing a futures piece is risky; I will be wrong in many cases and on re-reading this paper in ten years we will laugh at both the obvious things missed and the impossibly naive and optimistic claims that are included. The case of the Internet is humbling in terms of anyone's ability to predict: although many of us have been fervently dedicated to networking and its applications to education, we totally missed the significance of the standardization that led to the Internet and its explosive growth in the last year. The most likely result in ten years will be that we are only a fraction of the way along most of the optimistic predictions; that education has, once again, demonstrated its imperviousness to change.

Assumptions

First let's speculate about the infrastructure that will be available to support educational applications. We start by looking not at the networks themselves, but at the computers that students will have, for the whole point of digital networks is to interconnect computers. Next we imagine how networking resources will be made available to these computers.

Hand Held Computers

Networking and computers are intertwined in so many ways, it is difficult and pointless to separate out the specific contribution of networking. A prime example of this intertwining is the way ubiquitous networking may finally help the small hand-held computers[1] come into their own. The network can reach hand-helds through a simple serial wire, infrared, or wireless digital radio and turn them into Internet clients and servers. With this capacity, a student can hold the entire

[1] What shall we call these? The term Personal Digital Assistants, or PDAs, has become popular, but is inappropriate; it implies that these are not really computers, but something else that just helps you. This is already not true; the HP 200, for instance, is a full computer that runs Windows. I will use the less-glamorous but more descriptive "hand-held computers", or simply "hand-helds".

cyberspace infosphere. There is no need for hard drives for on-board personal files, no need to squeeze in an encyclopedia or huge databases, no need to have computational muscle; these capacities can be at a remote server. The hand-held need only be large enough to run a browser (which, granted, will be large).

It is important to understand the difference to students between today's reality of occasionally using a computer in school, usually as a member of a group, and the future where students will always have their personal hand-held computer available. Few students today have sufficient exposure to computers to become fluid with them, to begin to use them to enhance personal expression and understanding. For most students, the term "personal computer" is a misnomer; students use "institutional computers." Each class involves a different computer, so there is nowhere to store their work. In fact, for the casual student user, the computer, instead of facilitating thought, can have the opposite effect, it can inhibit expression and simply become another barrier to understanding. When a student no longer has to think about the cursor, understands what the computer can do, and has mastered a few productivity packages, when everything the student has ever thought, collected, written, drawn, or composed is easily available, then the computer ceases being a problem and starts being part of the solution.

Hand-helds cost only a few hundred dollars now and will drop quickly as a mass market develops for ones with Internet browsing capacity. When this happens, each student can finally have a personal computer, one that can go anywhere and do almost anything. This, in turn, will begin to make it possible to realize major changes in education that have been promised by computer advocates for so long. Educators will be able to utilize information technologies in ways that are difficult to imagine in today's computer-starved classrooms. There will soon be schools where all students have their own, networked computer that they can use year in and year out at home, in school, in the bus, on vacation, and in the family car. For these students education, especially science education, can be much richer and more interesting and meaningful. Networking makes it possible for this to happen soon with affordable hand-helds and it makes these computers far more useful than they would be without connectivity.

Over the next decade, hand-held computers will change a great deal, so it is unreasonable to use the current models as a guide. What is now available will bear the same relation to hand-helds at the end of the decade that the Apple II does to the latest Mac. CPU power will increase by a factor of 100, as will networking bandwidth and memory capacity. Wireless networking will be common, so students will have the full resources of the world at any place. And, because they are small and mass-produced, hand-helds will be less expensive than desk-top computers. Thus, it seems reasonable to assume that the most common educational computers in ten years will be small, networked, hand-held computers.

Pipes, Servers, and Clients

Wide bandwidth digital networks–pipes–will reach into every home and school in a decade, whether the data is moved over the power line, cable, telephone, satellite dish, fiber, or dedicated digital line. In homes, these pipes will terminate in a server computer that might called a set-top box because a TV will be connected to it. But the server will do much more than simply provide a TV signal, it will also provide network access to all the computers in the home, including the kids' hand-held computers, using wireless, infrared, and wires. Schools will also have ubiquitous networking, so that no student will need to carry files in a hand-held computer, but can have full access whether at home or in school. Synchronous and asynchronous communication among students locally and worldwide using combinations of speech, text, drawings, and pictures will be commonplace. Two-way video, because of the demands it makes on bandwidth and simultaneity[2], will be expensive and less-used outside business. The most common piece of software will be client network tools descended from today's browsers, that integrate access, authoring, and application control. The huge market for these tools will ensure interoperability between platforms and networks, creating a network as seamless and transparent as the current telephone network.

Applications

Because of applets and improvements in client software, networking will evolve to become highly interactive and responsive. This will give learners easy access to inquiry tools such as spreadsheets, graphers, symbolic processors, and all kinds of simulations. MBL interfaces will be available for networked hand-held computers, allowing students to study a wide range of phenomena outside the lab in classrooms, corridors, playgrounds, athletic fields, streets, homes, streams, fields, and forests. Scaffolding applications will help beginning students organize their inquiries and reflect on their learning.

Payment

The information highway is now, first and foremost, an advertising medium crowded with billboards, where the pitches vary from the hard-sell of auto dealers to the soft-sell of people and institutions vying to be known by being helpful. Soon, there will be billboard-free toll roads and many of these will have educational value. These will be important to education because most useful education resources take people-time to create, operate, maintain, and update, and they involve intellectual property that often needs income reward. Some of this time and property will be provided free by public-spirited volunteers, foundations, and companies. But this will always be a small and unstable fringe effort, rarely able to scale up to have a significant impact on education. All the large-scale, network-based educational programs will be on a fee-for-service basis.

Most good education involves irreducible human costs. Students may be able to communicate with scientists, but not many–this will not be significant on a national scale. Discussion groups need moderators. In essence, student understanding must be known by someone and that person needs to be compensated. As a result most

[2] Many people assume that the asynchronous nature of most of the Internet is a temporary aberation that will be fixed with higher bandwidth. On the contrary, we have stumbled onto something that is usually more valuable, asynchronous communication. While not as rich as symultaneous communication, it is so much more convenient that it will dominate in the future.

resources that can be scaled to reach large numbers of students will cost money that, eventually, the end user or society, in the form of public education, must be willing to pay. Network resources, because they involve bits and not atoms, will be less expensive than their physical counterparts; in effect, textbook funding will be transferred to network resources.

Extensions of Traditional Functions

So, given that computers and networks will be intertwined and could be in wide use by students and teachers, let us examine first what kinds of resources they will offer educators and how these resources might impact science education. Most of these resources will be similar to those that exist today, only available on the network.

The Cybrary

Right now, the greatest benefit of networks are all the new archival material they offer to educators: references, articles, curricula, books, and catalogs. These resources will continue to grow as the network is increasingly seen as an ideal publishing medium for references, instructional materials, and thin-market material.

The amount of information on the networks is growing at a staggering rate. A sampling of resources of potential interest to math and science students are the following:

Weather and climate information. Current weather images, predictions, and data are available from many sites. Student can not only get current weather, they can view data about el Niño and ozone.

Science news. Regular articles and press releases about advances in various fields of science are available as events happen. For example, the images of the Schumaker-Levi collision with Jupiter were accessed by over a million users.

Mandelbrot set viewer. You can view the Mandelbrot and Julia sets at several orders, any location, and from any magnification. This is different from other references because there are an infinite number of computed pictures that can be generated.

Databases. Students can find where the local Superfund sites are, download historical smog levels at their location, explore the production of methane by country, study census data, and examine raw data from the top quark experiment at FermiLab.

The number and variety of these kinds of resources are certain to explode. The Library of Congress will be on-line, as will all scientific, natural resources, and geo-political data. All non-copyrighted books will be free and most copyrighted books will have small use charges, many of which will be waived for students.

Hot Lesson Plans

On-line lesson plans will become an important way for teachers to share ideas for the use of the network. Already, some are on-line, but few have links to other network resources. As teachers gain familiarity with network resources, they will increasingly describe how they weave multiple resources together with more traditional resources to address specific learning objectives. These descriptions, "hot lesson plans," will be on the network and contain hot links to other network resources used in the lesson. These will be of great interest to others and passed around the network like wildfire. The best will have a small royalty fee that offer authors the opportunity of an impressive reward given the number of potential users.

Current events with scientific implications, such as natural disasters, earthquakes, space shots, major discoveries, and astronomical events are topics that will generate particular interest when quickly incorporated into hot lesson plans.

Telecollaboration

Collaborative inquiry will take many forms, from scientist-led efforts like GLOBE, through student-led research. Collaboration will start in the classroom with students attacking different parts of a problem and sharing their results over the network. This will grow to include world-wide collaboration in communities of student-researchers of great richness and variety. Shared instrumentation available only through networks–remote telescopes, cameras on satellites, seismometers in schools, automated weather stations, tunneling microscopes–will greatly enrich the range of collaborations in which students can participate.

Netcourses For Teacher Professional Development

There will be an explosion of network-based courses for teacher professional development. The best of these will offer world-class learning opportunities that will intermix cognitive research, educational philosophy, subject matter content, and just-in-time support for in-class experimentation. Participants can work with local study groups and larger virtual groups that span the world. The faculty leading these will consist of teams that include international experts, experienced teachers, and outstanding researchers. Graduate credit from leading institutions throughout the world will be available for teachers. Part of the teacher evaluation will be based on curriculum and research contributions participating teachers make and post on the network. The result will be a growing teacher-generated literature of immense value to education and increasing appreciation for the role of life-long learning for teachers and teachers who are also researchers making contributions to education, science, and mathematics.

The availability of excellent graduate netcourses will substantially improve teacher preparation and professional development. With thousands of accredited courses available on-line, no teacher or prospective teacher will ever again have to suffer through a dull, meaningless course just because it is the only one available. That stuffy, old, sexist fogy, droning on from out-dated notes will have no audience. In fact, entire departments and schools of education will find themselves out of business unless they improve their teaching and scholarship, because their students will be recruited to stronger, more aggressive graduate schools throughout the world.

A note of caution here. There will be lots of junk graduate netcourses and net-diploma mills. The network will make it easier to get credit from impressive-sounding institutions for little learning and less effort. Teachers will undertake the extra effort to master difficult courses only when excellence in scholarship, knowledge, and breadth of learning are more highly valued by schools, communities, and unions.

Netcourses and Net Schools for Students

Netcourses in profusion will be available to students, ranging from little more than organized tours of network resources to sophisticated courses offered by scientific and educational experts. Some will be free while others will charge tuition. Guides will be available on-line who will interview students and recommend particular netcourses. Evaluations of the netcourses and even the guides will also be available. The availability of netcourses will provide much-needed choice at the upper end of the educational spectrum, but will represent a major challenge to the core educational mission of schools.

A large number of net schools–schools purporting to offer an entire curriculum–will also be created. Some of these will have their curricula consisting of other network resources, but offering professional guidance and solid evaluation. Many will be terrible, but some will be excellent, offering far better learning experiences than some local schools. The best will not be cheap, because there are irreducible human costs associated with education–essentially the cost of paying someone to understand the current intellectual level across all disciplines for each student and to be able to prescribe experiences appropriate for each. But, compared with comparable schools, quality net schools will be less expensive since they will have reduced physical plant costs, fewer administrative costs, and lower faculty costs because they use a mix of advanced students, volunteers, and low-cost international expertise.

Evaluation

The network offers many ways to support improved student evaluation. Student portfolios can be on-line and subjected to peer and external professional review. The network offers many new opportunities to automate and track inter-ratter reliability, increasing the pool of potential evaluators and the consistency of their judgments. It is likely that network-based, for-fee evaluation services will spring up that will both have the confidence of colleges and universities and also offer a far more thoughtful and intelligent way of evaluating student work than the current over-reliance on "objective" tests. This development will have a major impact on teaching throughout the pre-college level, relaxing the need to have a nodding acquaintance with many topics and rewarding thoughtful engagement with a few.

There will also be valuable network-based tracking and database capacities that will support evaluation. Imagine, for instance, that a learner wishes to have her experiences in one corner of the web automatically recorded for inclusion in her portfolio. An automatic tracking utility might be able to note what kinds of information the student was exposed to, sample some interactions, and record exemplary work at the student's request. The resulting record, itself a hyper-linked network resource, would be invaluable to students, teachers, and parents.

New Functions

Perhaps the most interesting, and potentially important, developments will be those that are unique to the networks and depart strongly from what is currently available. These are, of course, the most difficult to predict.

Guides and Agents

It seems clear that future network users will suffer from infoglut; the volume of resources available on the Internet will be completely overwhelming. There will be lots of gold, but more fools gold, tailings, and junk. If you search for evolution, you may get Darwin's Origin of Species, 4th grade essays, creationist dogma, and erudite scientific papers. Mediocre and dreadful resources that will be on the networks in far greater quantity than the excellent, as always. There will be lots of drill and practice, courses that preach radical relativism (your theory is as good as mine), and untested student activities by the terabyte generated by teachers of all degrees of competence. Every government agency, every lobby, every professional society, every public interest group, will generate network-based units that cover math and science topics that support their world view. NASA already sells space platforms thinly disguised as instructional material; the nuclear industry will convert its units on the virtue of nuclear energy, as will the coal, natural gas, and corn/ethanol lobbies. The religious right will champion creationism and produce biology material innocent of Darwin and sex; racists will have units on the genetics of Lamarck and Schotkey. Old and out-of-date textbooks will be copied wholesale onto the net and sold.

There will soon be hundreds of network activities that will advertise hands-on, computer-based, collaborative project activities based on constructivist principles and consistent with all the standards. A few will be excellent but the vast majority will be junk. It's easy to generate the form without the substance: to create hands-on activities that result in thoughtless manipulations, computer use that degenerates to competitive games, network collaboration that goes no further than pen-pals, student projects that only require students to mindlessly cut and paste net resources, constructivism that devolves into ignorance, and material that "mentions" lots of items in the standards just to make sure there is content "coverage."

With lower costs of publication, these dregs will flood the networks. Because it is easier and faster to produce bad material than good, the junk will be there first, giving educational networking a black eye.

The strengths of some resources and weaknesses of others will not be obvious without extensive study and thought. This will create the need for guides to the material. But no one guide will be satisfactory for all, so there will be many. Some will be self-appointed, some will represent professional societies, and some will be subsidized by organizations with various slants on what needs to be done to improve education. Many of the guides will have crazy or ideological slants. There will be a need for guides to guides, and guides to these. Perhaps the most valuable evaluation services will be offered by insightful professionals who derive their income solely from the quality of the evaluations they provide.

Some hope that there will be technological solutions to the glut of network information in the form of intelligent "agents" that learn what you want and search the network for matches. I doubt it. Certainly, searches will get better than the literal word-matches currently required, but they will never evolve to the point that even the most rudimentary understanding would be required. As a result, we will continue to rely on the recommendations of thoughtful people we have learned to trust. The only thing the network adds is that these experts can be anywhere.

Virtual Museums

Science and technology museums are beginning to move onto the net. Within the decade, every museum large and small will have a network presence. They will have to do this to attract visitors to their physical sites and to extend their impact.

The obvious approach many will follow will be some sort of telepresence which attempts to duplicate the museum experience over the network, using pictures and three-dimensional, walk-about software like Quick Time Virtual Reality. The more thoughtful approach will be to re-think the educational role of museums and to re-cast that using the strengths of network capacities. Highly interactive simulations, games, and collaborations will result, as well as access to archives and otherwise unavailable material. The collections of individual museums will be inter-connected with hyper-links into a huge, rich storehouse of highly accessible knowledge as well as vast oceans of unassimilated holdings students can chew on. Once again, some of this will be free, but the best will charge a small fee that helps offset maintenance and development costs.

This body of informal learning resources will interact with formal education in many ways. Netcourses and net schools will draw heavily from the virtual museum resources, creating paths through these that add up to courses and entire curricula. Schools will be able to plan coordinated virtual and real visits that will result in far more learning.

Impacts on Science Education

As we try to understand what the most significant impact of all these resources will be on science education, let's not forget that "Better learning will not come from finding better ways for the teacher to instruct but from giving the learner better opportunities to construct." (Papert, 1990)

The extent to which the capacity of information technologies goes beyond simply telling students and presenting information, is the extent to which it will truly change education. Indeed, as we have seen with computers, the best utilization of information technologies requires a substantial restructuring of the classroom, of student evaluation, of teacher training, and of the apparently immutable external pressures from colleges and standardized tests. The likelihood of dramatic, widespread change in all these is remote; better schools and inspired teachers will, as always, cause changes to happen in important but isolated instances. But the vast bulk of schools will continue to ignore these wonderful resources, just as today they ignore many existing excellent print and software resources.

Therefore, let us first imagine what the very best, most flexible, risk-taking schools will do with these resources, and then ask how the rest of education will be influenced.

Science in the Best Environments

If we survey science in the very best learning environments in 2005, I hope that we will see totally different content, supported throughout by technology. Information technologies will be used as enablers to learn **with**, just as books, pens, and labs enable learning; but few kids will actually be learning **from** a networked computer.

In general, I dream that we would see students involved in a variety of virtual communities, the engagement of teachers as lifelong learners and researchers, the use of on-line student portfolios and assessment, and regular use of the full range of network resources. I hope that teachers will talk of their approaches as far beyond what was called for in the science standards in the present era and that their assessments of students will be endorsed by the best universities and colleges as far better predictors of creativity and life-long success than the SATs and APs.

A whole new class of information organizers and intelligent scaffolding software will help students structure their ideas and reflect on their thinking. These will finally help realize the promise of metacognition, understanding how you think and learn. With help from information technologies, we will learn how to integrate increasingly sophisticated concepts about thinking into the curriculum with the result that students will learn to learn much sooner and with much greater insight. This insight will greatly accelerate what students learn and their ability to learn from the disorganized resources present on the Internet. When this personal skill is combined with the full resources available, the result could well force a total re-thinking of what can be taught and when.

In this imaginary tour of best practices, I have purposely avoided assuming that the learners surveyed will be students in traditional schools with grades. While there will continue to be students and teachers, the network will support many more combinations of physical locations, ages, and occupations. Some students will be in familiar graded schools, others will be at home, while other will be adults on the job.

The following is a highly speculative picture of what might result at different levels:

Elementary Material

Information technologies will have supported a full integration of experimental science with mathematics around beginning student projects and investigations. Starting at six years old, kids will be designing and carrying out their own technology-rich investigations, gaining experience with materials, design techniques, measurement, error analysis, and interpretation. This will be followed by the introduction of graphing and graphing analysis, starting when kids are about ten, using data gathered from real-time probes used in microcomputer-based labs (MBL). We will also see far earlier introduction of decimals in the context of experimental measurement at the expense of fractions (which will be treated as an anachronistic novelty in one week in the middle level.)

Experimental probability and statistics will be introduced with the earliest experiments, and then, building on their computer-based numerical and graphical skills, treated quantitatively beginning around age eleven. The resulting measurement and analytic skills will enable eleven- to thirteen-year-olds to explore a range of scientific areas through observation and measurement. These explorations, some as part of networked groups, some with MBL, will have given students a broad exposure to examples of categories, change, regularity, and cause and effect in the natural world. Kids may not have realized it, but some of their activities involved pre-engineering design challenges.

Middle Years.

Because of the elementary curriculum, mathematics at middle levels (starting with kids thirteen to fifteen years old) will be freed from much of the beginning algebra abstractions and will, instead, concentrate on numerical modeling, estimation, and, later, the use of algebraic formalism, particularly with the help of graphers and symbolic manipulators. Transcendental functions will emerge incidentally from dynamic models as particularly simple systems. Feedback and control will be central themes introduced in design problems and formulated into the dynamic models.

The concentration on modeling, particularly dynamic modeling, will provide a key underpinning for a range of scientific theorizing, since dynamic models with feedback help students predict the future of everything from astronomy to the stock market, global warming to school demographics. This will give kids a technique to move between quantitative observations to theory that they will find powerful and general. Experimental investigations will continue to mature as the students mature, enabling them to increasingly coordinate multiple variables in various disciplines using increasingly sophisticated measurement techniques supported with network materials rich in images and video. With increasing exposure to measurements in various fields of science and technology, kids will be able to design their first extended investigations and share their thinking and results with others with similar interests throughout the world using programs like the Global Lab and GLOBE which involve global data collection and sharing with students and scientists who are interested in their results. Technology and design challenges will be plentiful, but not separated from the experimental design and information technology skills these learners will develop as part of their investigations.

The Precollege Years

The prior treatment of algebra, graphical analysis, and dynamics will free new space in the precollege curriculum for a real mathematics sequence, where the goal is not applied mathematics, but the exploration of mathematical reasoning for its own sake. This sequence will combine experimental axiomatic geometry and algebra with the formalism of calculus, all making extensive use of computer tools, and network collaboration based on specialized interests. Some learners will, for instance, join a hyperbolic geometry forum to share problems and proofs. There will also be an applied mathematics sequence that advances student ability to deal with computer-based numerical methods, statistics, multivariate data visualization, image analysis, and geographic information systems. Many of these topics will draw on real data from the network and from student investigations.

In science, students will find support on the net for increasingly sophisticated challenges. Many of these will require considerable background study which will be provided as needed through a rich set of modularized, just-in-time units which will be available. Opportunities for original work using networked telescopes, seismographs, scanning microscopes, and supercomputers will be commonplace. Students will contribute to and analyze global environmental datasets, polls, and other network science projects. Learners will collect their best work and evidence for skill mastery into portfolios that will be available on the network to teams of evaluators. These external evaluations will change the relation between students and their teachers who will increasingly be seen as allies and guides. These evaluated portfolios will become the primary evidence used in college admissions and job applications.

Science in Most Schools

Network resources may have a different effect on mediocre and substandard schools by creating out-of-school alternatives that are more attractive and clearly more valuable than the local school. The competitive nature of these resources will undermine the monopolistic hold schools have on their communities; schools will either have to become excellent or face the extinction of their educational role. The pressure to compete will come in several forms: pressure for better courses, vouchers, and home schooling.

The first pressure will be on courses that are difficult to staff. There will, for instance, soon be hundreds of physics netcourses for students to choose from. For the school without a qualified physics teacher or for the disgruntled student who cannot stand to be lectured by the one the school has, there is certain to be at least one far superior netcourse alternative.

When there is sufficient quantity of quality netcourses, the most telling argument against school choice and vouchers—the lack of choice in poor districts—collapses. Network resources can be anywhere, provided the computers with network access are available. And at least some of these resources will be relatively inexpensive, enabling even the poorest students to enroll.

Home schooling will become more attractive when network resources become available and this alternative will pressure schools to increase their quality or face widespread public rejection.

These competitive pressures coming from the network will improve many schools. These schools will use their natural advantage of history and locality, draw on the excellent network resources, and emerge stronger. Some ambitious public and private schools will even extend their borders, accepting, for tuition, students from anywhere, with preference given to create multicultural virtual groups. They may find the added income actually reduces property taxes to the delight of their towns.

Parents in some failing districts will demand wholesale in-school netcourses and shift the primary functions of staff in these schools to providing the technology, advising, proctoring, and sports. In other cases, parents will demand and get the average per-student expenditure as chits they will use outside the existing public school structure for qualified netcourses and netschools.

Of course, these more radical changes will improve the quality of student learning only when there is sufficient wisdom and sophistication in communities to find the little good on the net and reject the many slick but inferior network-based educational packages that will certainly be pressed on districts and parents. Edutainment will be trumpeted as a harmless way to learn and have fun on the net; complete netschools backed with impressive educational pseudo-research will be sold to unsuspecting districts. Insidious advertising will slip in as a way of reducing the costs.

The availability on the network of excellent materials, even if almost drowned by junk, may excite discriminating parents who might pressure schools to do better. Of course, the opposite will happen more frequently; the stern parent will find justification on the network for more disciplined learning, as will the creationist, white supremacist, and every other crazy faction. Communities without the resources to have discriminating educators and parents will transfer to these plentiful but inadequate network resources, thereby trading one poor educational strategy for another.

In some cases, telecommuting will replace bussing programs. This is, of course, regressive from a the view of the larger society. All forms of distance education can be means of retaining ghettoized housing patterns and reducing social contact between racial and ethnic groups while addressing educational inequities. Moderates will argue that we cannot burden education with trying to solve all of society's problems; it is true that fair and equitable educational opportunities represent a great goal that, with the current savage inequalities, remains too far out of reach.

Whether these new network-based resources have a positive effect on science education depends on the way they are used and who has access. The new resources, the new opportunities for inquiry, collaboration, and metacognition all support the kinds of learning that many schools have found difficult to offer. On the other hand, if these technologies are implemented by sacrificing needed equipment or in-service support, if the most popular netcourses are heavily fact-oriented such as SAT prep courses, if students become "data robots" for scientists, if less time is spent in hands-on investigations, then nothing will be gained. About all one can reliably predict is that well-funded and well-run schools will be more likely to implement the better applications of networking, while the rest will do nothing or implement the less-progressive applications.