Newsletter
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INSIDE

Teaching & Learning in the Knowledge Society

Putting technology at the service of content

by Robert Tinker

In order to design appropriate education for the next generation, parents and educators need to have a clearer picture of the future. There is little question that technology will have a huge impact on all aspects of our lives, but the level of discourse about its educational impact is singularly shallow. The educational needs of what has come to be called the Knowledge Society are a widely misunderstood integration of the traditional and the technological.

Alfred North Whitehead noted the central importance of knowledge in society as early as 1926. The post-World War II emphasis on near universal post-secondary education was based on the widely held view that advanced knowledge was essential in our society. While it is now commonplace to hear that we shall increasingly live in a Knowledge Society created by computers and networks, it doesn't mean that technology should be the central subject of study.

To understand the uniqueness of the 21st century Knowledge Society consider the nature of work before computers. Work shifted postwar from blue- to white-collar jobs, but much of the white-collar work consisted of repetitive, uncreative work in hierarchical organizations. Clerks, accountants, draftsmen, secretaries, salespeople, and many others went off the production line, but they remained in boring jobs. In the Knowledge Society, technology appropriates or vastly simplifies much of the repetitive work. My father, who headed a research organization, had four secretaries. I also lead a research organization, but I have no secretary because technology has made it unnecessary. What the Knowledge Society requires is cognitive generalists working in small organizations.

It is commonly assumed that the main social significance of technology is increased access to information. But information is seldom the limiting factor in our work. A huge increase in work productivity is the most important gain from computers and networking. A letter can be composed, checked, formatted, sent and received in a few moments. Research in support of a new idea can be completed in an hour. A complex proposal can be conceived and prepared by a global team and

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Knowledge Society

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completed in a few days. Architectural plans can be drawn, costs estimated, views generated, and materials ordered faster, better and with far fewer staff. Reams of files can be easily transported and searched in seconds. Complex models can be generated and thoroughly explored in hours.

My son is an investment banker who not only compiles much of his own research and analysis, he also communicates his findings to investors through attractive and informative brochures for which he serves as general editor, author, graphic designer and layout artist. Using his portable computer and the 'net, he performs these multiple tasks wherever he happens to be. Of course, I am prejudiced about his capacity, but it seems as though he does the work of several pre-computer age employees.

> "Too often the conclusion is simply to teach keyboarding, programming, and application use. This is nonsense."

The driving force of the Knowledge Society is increased creativity and productivity in working with information. While increased information use generates a need for more information, the greatest impact of these changes is that the knowledge worker is more effective and needs less organizational support. Whereas specialization was the key to post-war information age progress, the technologically savvy generalist will flourish in the 21st century Knowledge Society by needing less support and working in smaller, more democratic organizations.

It is no accident that in the United States today jobs are being created faster than ever while at the same time many huge corporations are cutting personnel. The usual explanation for the contradiction blames the phenomenal and continuing pace of change. While it is true that small organizations are more nimble than large ones, the reason for the change is that there are major diseconomies of scale. In centralized bureaucracies, decisions and leadership involve multiple layers of management and numerous people. These are expensive and slow. Large-scale organizations were important in order to coordinate huge teams of specialists, but this structure is outdated in sectors where a few generalists can get the job done.

What does this mean for education? Since it is obvious that technology will reshape the future, educators assume that students must therefore master technology. Too often the answer is simply to teach keyboarding, programming, and application use.

This is nonsense.

It is a fallacy to think that technology will make traditional content outdated and we therefore should shift from content to teaching how to learn new things. The corollary to this thinking is that traditional content is less important than learning to learn. This is a dangerous doctrine.

The goal of liberal education has always been to produce creative, original thinkers, and the age-old wisdom is that this must be done from the broadest possible knowledge base. Nothing in the nature of technology has changed that wisdom. The Knowledge Society demands generalists who have many of the intellectual skills associated with a classic liberal education, thoroughly adapted to infor-

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Envisioning Reform

INTEC uses inquiry-based learning and teaching for math and science

by George Collison and Sarah Haavind

I realized we were representing one of the most common formulas of Algebra II:

$$(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$

I had used this formula for 30 years because I was told to memorize it and was taught where to apply it, but I never really understood what it meant. This is very exciting and mind boggling to suddenly, after all these years, make a concrete representation of the formula.

This high school mathematics teacher is experiencing inquiry-based learning and teaching for the first time. As a participant in the International Netcourse Teacher Enhancement Coalition (INTEC), a professional development NetCourse™ designed and produced at the Concord Consortium, she is describing a powerful and critical shift in her understanding. The familiar mathematical and scientific preconceptions of the past are being replaced by discovery through inquiry, an experience that is sure to affect her classroom practice.

The most exciting aspect of this kind of discovery presented in this kind of format is its potential for serving individuals and their larger communities (department, district, or colleagues statewide) equally well. Since INTEC offers coursework over the Internet, individual teachers have anytime-anywhere access to content and colleagues. At the same time, districts and states can take advantage of an affordable 'net-based professional development course.

Web-based instruction has had well-documented drawbacks: personal contact and classroom dynamic are often sacrificed for a text-based environment viewed on a computer screen. But we believe that a successful educational design must combine the global, scalable strengths of web-based instruction with small, local groups of educators who question, improvise, share, and refine strategies collectively. Intellectual interaction with their larger professional community is essential for validating ideas and helping teachers to improve their practice.

The basis of this perspective is the belief that reform in mathematics and science education is forged locally, in the practice of teachers. INTEC has researched the state of the art in professional development netcourses and we have refined the traditional format in order to create a more viable model where dialogue and momentum gained online recycles through the face-to-face group meeting, perpetuating growth at the local level.

In their article "Teaching Physics On Line," Richard Smith and Edwin Taylor emphasize creating bite-sized assignments and planning as critical elements of netcourse design. Building on this formula, we added some key elements.

A Seminar Model

For cohorts of about twenty (comprised of groups of four to six in one building or district), INTEC offers such common experiences as readings, online simulations and discussion, along with local activities and dialogue. Interaction with the web community resonates with personal insight and serves as a catalyst for local growth.

This participant describes his understanding of these goals:

Two key words—explore and discover! We often make excuses for not allowing time for students to do these two key things—it takes too much time, they won't be able to handle it, discipline problems, we won't be able to cover those hundreds of standards, etc. However, we all had fun doing this activity. I think the more experiences I had working with the cubes, the more comfortable I became and the less frustrating the activity became. It is taking me less time to reach a successful output. My knowledge has increased and deepened with each activity, building upon previous experiences.... This is what we want our students to do—construct knowledge from the stimuli we provide.

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INTEC—www.concord.org / intec

NetCourse—www.concord.org / intec / faq.html#num1

Teaching Physics On Line—www.montana.edu / wwwxs / netscape / edwin.html

Envisioning Reform

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Lotus DOMINO

A new interface, Lotus Domino, enables INTEC participants to attach to an online discussion posting any document or file (including simulations) to view, launch, and discuss. Items created by teachers or students support a rich new mode of web-based discussion and exchange.

A participant posted this message to his cohort:

Those who really have a background in standards-based education, here's my challenge to you: how do you convince your students each year that understanding is more important than memorizing?... Here's my second challenge. I'm going to attach my outlines on teaching negatives without rules. What are your comments on how you might manage these lessons?... Note: I am convinced that negatives are a measurement concept, NOT a counting concept. So please don't suggest manipulatives based on counting concepts unless you are prepared to justify the association between counting and negatives.

Face-to-Face Meetings

INTEC has tempered the main criticism of "distance learning" (that it shortchanges personal interaction) by adding a face-to-face component to our NetCourses. After working with a local group on an inquiry activity, one participant noted:

***The Craters!* experiment was fun to do and a learning experience for me. At first the experiment appeared to be useless in the sense that the bolides did as expected. The value of the activity was not in the weighing or dropping of the bolides or any other part of the experiment. For me, the value of the experiment was in the discussion that followed.**

Another participant concluded:

It amazed me all the different levels of mathematics that could be used in a student discussion. This realization emphasized the breadth of usage across grade and / or ability levels. For instance, some of us could see that basic similarity properties could be the focus of the problem or we could raise it to the level of trigonometry or even hyperbolic multi-variable functions!

International Netcourse Teacher Enhancement Coalition

www.concord.org/intec

More Than Text Online

Here are two examples of how INTEC has moved beyond text on the web for curriculum delivery:

1. INTEC has incorporated web-based assessments called "conceptual probes," that seek and document students' common science and mathematical conceptions. These are probes not unlike the research interviews from the Annenberg study, *Private Universe*. The web versions organize and display student responses for teachers researching the conceptual understanding of their students.
2. Dynamic elements like animated images serve as "how to" demonstrations of software simulations. Sequential steps for construction of objects can be shown rapidly in a graphical interface without reliance on lots of computer memory or power. For instance, when building an ecosystem with Environmental Decision Making, participants who need to know how to add sunfish to a pond can access an animation of the process.

Moderators and Field Experts

The INTEC model also includes an expert moderator and field experts who support the online discussion. Moderators are guides, not content experts. They encourage participants to initiate topics of interest, ask probing questions, pursue unpopular positions, and engage in deeper inquiry investigations that challenge interests and current understanding. Field Experts are mentor teachers who have worked in classrooms with the curricula INTEC participants are exploring.

A Concrete Product

Each INTEC participant selects one of the eleven exemplary National Science Foundation-funded or commercial curricula to study in depth. They produce an inquiry-based unit and try it during the final practicum component of the course. Teachers challenge themselves and the field experts with questions such as "Where is the value added in an inquiry-based approach?" and "How do I know what the students have learned?" Their discussion and their plans for use of the curriculum provide concrete and locally relevant answers.

What Is the Impact?

The INTEC NetCourse builds on collective insights and contributions. On site and through the web, strategies are shared and a vision of reform is assembled that pays attention to local

LINKS ON THIS PAGE

Private Universe—www.learner.org / collections / mathsci / teachers / pup /
Environmental Decision Making—www.concord.org / intec / t3 / bq / BQmg5.gif
National Science Foundation—www.nsf.gov
Lotus Domino—www.notes.net

conditions and support. At the INTEC web site collaboration and growth online are facilitated by the local face-to-face meetings. Teachers experience themselves as learners of useful inquiry methods . . .

Too often we like to present concepts to our students like a big pill.We expect our students to swallow it without any problems. We know that students do have problems.... Can you imagine chopping the pill into smaller pieces? Do you think that it would be easier to swallow? INQUIRY, I feel, is that knife which can chop and allow for the students to digest. INQUIRY is not so frightening as that BIG PILL.

. . . and learners of mathematics:

I always thought I wasn't a smoking gun in math. However, I realize that as we progress through these activities, I've gotten pretty good! I had few difficulties with this activity compared to the first times. . . . These experiences have also spilled over into the college algebra class that I take at night; I feel much more comfortable there as well and have been trying to experiment with the cubes to enhance my own math experiences.

They revisit familiar content issues and cultivate and value a new vision of assessment.

Will INTEC Work?

Assessing the value of the INTEC course lies in classroom practice. The product of the discussion and the final practicum must exhibit the use of inquiry methods, pushing beyond trodden prescriptions towards a new kind of teaching—the green, growing edge. Units must integrate disciplinary knowledge and bring together themes and concepts, rather than satisfying factual mastery. Most importantly, the inquiry must be a part of teachers' assessment goals for students.

For the INTEC participants, insights from their own experience of inquiry have opened a window. One participant reflected:

We learned our math in isolation from concrete concepts; our math was always esoteric and intangible. Here the blocks led to the formula and I saw a simplicity and natural connectedness between the two that was beautiful.... I now have a concrete way of describing each of the terms of the formula and more importantly I understand the connection between the physical and mathematical world much more intuitively. Now how would I tell another teacher to use this important concept in their classroom?

Another suggested:

...Inquiry can be scary. I agree and then I say let's scare our students a lot.... The class participated in a real experiment. They did not know the outcome before they started and NEITHER did the teacher. This was real and this is how real science is carried out.... If a scientist knows what will happen before starting, we call what he is doing a demonstration.

Is there a place in the classroom for the unknown? Individual classroom teachers who entertain this often uncertain and even scary potential are the only means whereby inquiry-based learning can reach students. Through local and virtual communities INTEC is attempting to meet the challenge of the late Lewis Thomas:

It is the very strangeness of nature that makes science engrossing, that keeps bright people at it, and that ought to be at the center of science teaching. I believe that the worst thing that has happened to science education is that the great fun has gone out of it.... Very few see science as the high adventure it really is, the wildest of all explorations ever taken by human beings, the chance to catch close views of things never seen before, the shrewdest maneuver for discovering how the world works.

Unfortunately, the wildest of explorations has been squeezed out of most mathematics and science education. In the rush to put more content into education and to prepare students for the next exam, the essence of teaching has been lost. Can we regain it? Our belief is that NetCourses will make that dream come true again. @

George Collison created the INTEC course. Sarah Haavind co-develops and produces INTEC curriculum on the web.

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Strategies for a Sustainable Future

Technology-based education helps shape the world of tomorrow

by Jack Byrne

Optimism is a strategy for making a better future. Because unless you believe that the future can be better, it's unlikely you will step up and take responsibility for making it so.

Noam Chomsky

Where will the jobs be in ten years? Where will population pressures and emerging diseases be found? Fifty year from now, will there be enough gas to drive cars? What has to be done to save our national parks for the enjoyment of future generations? Will our cities be livable? Our air breathable?

Teaching students to ask questions about their future presents educators with a monumental challenge. Even most adults are poor at consciously shaping their own future. It's hard to plan for what we can't visualize. And according to B.F. Skinner, even when we do plan, those plans are not an effective reinforcement to assure change. Future thinkers such as Paul Ehrlich and Robert Ornstein suggest that we have evolved to make decisions of immediate or, at best, short-term importance, rather than long-term survival.

In the face of these challenges there has emerged the idea of sustainable development, a concept and practice which has become increasingly popular over the past ten years. The most widely recognized definition of sustainable development comes from the 1987 report "Our Common Future" based on the findings of the Brundtland Commission for Environment and Development: "development that meets the needs of the present without jeopardizing the ability of future generations to meet their needs."

One of the more insightful observations of the movement toward sustainable development comes from Tom Davis of the College of the Menominee Nation in Wisconsin:

The task of those who believe that the idea of sustainable development is more than a pleasant fiction is to construct a model of sustainable development based upon the characteristics of an observable model, even if the model is incomplete. The value of such a model is that it can be used to eliminate some of the fuzziness surrounding the idea of sustainable development and can also be used to encourage policies and practices that can, really, lead to a more sustainably developed world.

New high tech tools can help plan for future challenges: modeling tools that see trends and make predictions; decision-making tools for role playing; and computer-driven tools for quickly visualizing future scenarios. The Center for Sustainable Future (CSF), a new part of the Concord Consortium, has begun to

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College of the Menominee Nation—www.menominee.com / sdi / sounds / posoh.wav

Center for Sustainable Future—csf.concord.org

Education for a Sustainable Future—csf.concord.org / esf consider these new tools and how they can be used in the classroom to teach students about sustainability.

CSF is located on the grounds of the extensive Shelburne Farm in Shelburne, Vermont. Its first project is Education for a Sustainable Future, a five-year effort to define, develop, test, revise, and widely disseminate a broad range of excellent materials for sustainable development education. The project was recently funded through a U.S. Department of Education Technology Innovation Challenge Grant to a Georgia consortium consisting of the Cobb County School District, Marietta City Schools, Fulton County Schools, and the Concord Consortium. The project participants will pilot and refine the materials first in nine schools, then expand across seven districts, and finally support dissemination nationwide.

The Concord Consortium's "Sustainable Future" project is developing its model using work done by the President's Council for Sustainable Development and others. The Council's demonstration project, the National Forum on Partnerships Supporting Education about the Environment, defines education for sustainability as "a lifelong learning process that leads to an informed and involved citizenry having the creative problem-solving skills, scientific and social literacy, and commitment to engage in responsible individual and cooperative actions. These actions will help ensure an environmentally sound and economically prosperous future." The Sustainable Future model will reference aspects of that definition as we develop materials and technology tools for learning and teaching sustainability over the next five years. These tools will be used to build stronger bridges between the classroom and business, and between schools and communities.

The Sustainable Future project has assembled an impressive group of advisors, some of whom target one or more of six topic areas: stewardship of resources, visioning and planning, thinking about the future, designing sustainable communities, economics, and global issues. The first project-at-large committee met in January during an ice storm in Shelburne, Vermont, where meeting in the dark brought a quality of truth to the more dire scenarios of sustainability!

Essential to the conduct of the Sustainable Future project is technology. It provides the collaboration tools to bring international expertise to the schools, to support teachers as they develop, to implement the materials, and to disseminate the resulting materials. Using an educational strategy based on student inquiry, the project will adapt a mix of existing general purpose software tools and three exciting new tools developed specifically to help students visualize and explore possible futures. An evaluation of existing software is in progress and initial design characteristics of the new software is also underway.

The Center for a Sustainable Future will be staffed by Keith Wheeler and Jack Byrne. Keith comes to us from the Global Rivers Environmental Education Network (GREEN) where he was the Executive Director. Keith brings an abundance of knowledge and experience within the field of sustainable development and skills in corporate relations. He serves as co-Principal Investigator for the project. Jack Byrne, co-Project Director, was Executive Director of the River Watch Network and has skills and experience in organizational development, fundraising, collaborative process and project management.

The Cobb County School team is led by Dr. Richard Benjamin, Superintendent of Schools and co-Principal Investigator for the project. Sue Brown and Bette Bush are Cobb's co-Project Directors. Lockheed Martin, BellSouth, AT&T, IBM, the Cobb Chamber of Commerce, Cobb Education Consortium and other corporations and organizations are contributing substantial human, technical, and financial resources to the project.

The Sustainable Future project is bringing together an energetic and growing team of people to accomplish the objectives of sustainable development education. We look forward to achieving the vision of equipping students throughout the nation with the skills, vision, and knowledge to become productive citizens and contribute to a sustainable, information-rich future. @

Jack Byrne is Project Director of The Concord Consortium's Center for a Sustainable Future and co-Project Director of Education for a Sustainable Future.

To receive a copy of "Education for Sustainability: An Agenda for Action," a publication of the National Forum on Partnerships Supporting Education about the Environment, send $5.00 for postage and handling to The Concord Consortium, 37 Thoreau Street, Concord, MA, 01742. For information on bulk orders, contact us at esfinfo@concord.org.

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BellSouth—www.bellsouthcorp.com
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Monday

Technology-En

“Population Modelin

by Robe

The most important factor in determining what the future will be like and whether it will be sustainable is population growth. Population determines whether there will be enough food and the demand for all other resources. Shrinking populations will produce many elderly too dependent on a small pool of workers. Regional differences in population growth can sow the seeds for strife and war. For these and many other reasons, a good place for students to start thinking about whether life on earth is sustainable is by having them understand population trends.

One could treat the topic of future populations as a debate. There are those who say that population decrease in developed countries where birth rates are already below replacement levels will be the major problem. Others are not concerned that the world population will reach 12 billion in 50 years. Still others project ever increasing population growth that could reach 100 billion by 2100, creating a crushing demand on natural resources. Students could review these and other positions and try to decide which view is most likely. But this approach gives students no tools that help them decide. They must fall back on authority or the most appealing rhetoric.

	A	B	C	D	E
1	Parameters			year	pop B
2	fertility	**3.3**	child/woman	**1995**	**5.77**
3	life expectancy	**65.5**	years	1996	5.83
4				1997	5.88
5				1998	5.94
6	Calculated values			1999	6.00
7	death rate	1.53%	per year	2000	6.06
8	birth rate	2.52%	per year	2001	6.12
9				2002	6.18
10				2003	6.24
108				2100	16.27

Figure 1. The upper part of the simplest population spreadsheet. Columns D and E continue down the sheet for 105 years to row 108. All numbers except those that are bold are calculated.

A better teaching strategy is to give students the ability to make their own population models and draw their own conclusions. They'll learn far more about current population issues while gaining the ability to make independent judgments. They'll learn how models work, how models can be validated, and how much error there is in projections. They will also learn the mathematics of dynamic modeling and get a good preparation for calculus.

For students who have only a minimal knowledge of mathematics, spreadsheets make understanding possible. Students can easily make their own population models using a spreadsheet and arithmetic. Technically speaking, we're talking about the Euler method of approximating solutions to coupled differential equations using finite steps—but don't tell your students that. All they need to understand is that they will project ahead year by year based on the approximation that each population stays constant during the year until the last day of the year, when it jumps to the next year's value. If each year's change is not much, the approximation does not introduce much error. If you're worried about the amount of error, the time step can be reduced to a month, a day, or even an hour. Clearly, in the limit of very small time steps, the error vanishes. That's called calculus!

Spreadsheet Models

Figure 1 shows how I recommend setting up a spreadsheet for the simplest possible population model. Just the upper left part of the spreadsheet is shown; columns D and E continue down the page to row 108 to reach the year 2100. The bold numbers are inputs that students alter to explore consequences. In this model, the fertility rate, life expectancy, starting year, and starting populations are inputs to the model. The values shown are averages for the world in 1995.

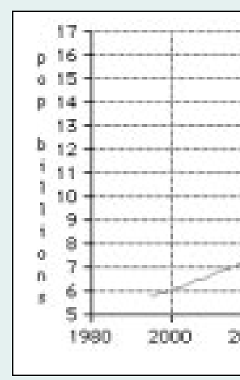

Figure 2. Create a graph ment with the results by e

Below the input parameters are some calculated values that depend on the parameters and are easier to use in the population calculation. The death rate is 1/B3, the reciprocal of the life expectancy,

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’s Lesson

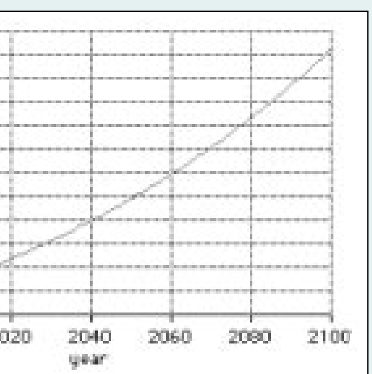
hanced Exercises

g with Spreadsheets”

ert Tinker

and the birth rate is 2*B2/B3. Do you see why? These values are based on the absurd idea that there is the same chance of a person dying regardless of age AND that birth rates are constant for women, regardless of age. We ignore these absurdities because 1) we care about the general size of the result and don’t expect it to be exact, and 2) we can always make a better model later to explore the impact of these assumptions. All models involve some simplifying assumptions. It is a good idea to have students understand this and the art of deciding what to incorporate and what to ignore.

Once students are content with the concepts of birth and death rates, the model is almost done. For each year, the new population is the old population plus the number of births, less the number of deaths. So, for instance, E3 is E2*(1+B8-B7). The dollar signs indicate that B7 and B8 are not to change as I duplicate the equation down the column, whereas E2 will change in each cell. By the way, set D3 to D2+1. Now duplicate (some spreadsheets use the term “replicate” or “fill”) D2 and E2 down 105 cells. Set your spreadsheet to generate an x-y graph from columns D and E. You should see a graph that resembles Figure 2.



using your spreadsheet software. Experi-
entering different data.

Once the spreadsheet and graph are constructed, students can experiment with different assumptions. Using the data in Figure 3, they learn a lot by projecting populations for different regions of the world. If these values continue unchanged, the world population will grow much faster than Figure 2 indicates, reaching over 47 billion in 2100! Why the discrepancy? Why was our first model off by a factor of three?

The problem is in the “lumped” parameters that hide high birth rates in some regions, particularly Africa. As students can easily discover, birth rate is the single most important parameter in determining future populations. It doesn’t make sense to build a model using its world average, because a region that has high birth rates will dominate future populations, in spite of short life expectancies. For instance, using the data in Figure 3, the model predicts that the population of Africa will jump from 13% of the world today to 76% in 2100. This is clearly impossible. Students should think about what might happen and what it means in terms of human suffering. Rwanda had a 1995 fertility rate above eight!

	1995 population	Life Expectancy	Fertility Rate
Region	millions	years	child/woman
Africa	744	53.0	6.0
North & Central America	419	72.8	2.8
South America	320	67.4	2.9
Asia	3,408	64.8	3.2
Europe	516	75.2	1.7

Figure 3. Parameters for different regions.

And They’re Off!

Clearly, better models are needed that account for trends in different regions, for the age of parents when children are born, and that allow fertility rates and life expectancies to change over time. With guidance, students should be able to construct and explore these models. If you are interested, samples of more complex spreadsheet population models are at our web site.

With some additional practice, students can go beyond population models and use the same ideas to construct models of almost anything that changes over time: a flu epidemic or world food production.

Students learn through the interplay between models and ideas. No model of the future is correct; it is simply a means of exploring the consequences of current trends and possible policies. By becoming comfortable with building and interpreting spreadsheet models, students gain the capacity to critically evaluate other models and to participate in thinking about the future. @

Robert Tinker is President of The Concord Consortium. For more information on modeling, see his “Teaching Theory Building.”

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Population Models—www.concord.org / pubs / 1997winter / popimg.html

Teaching Theory Building—www.concord.org / pubs / modeling.html

Is the Virtual High School "Educational Reform"?

by Bonnie Elbaum

What happens when you gather 30 of the nation's most innovative and risk-taking high school teachers together in a virtual learning environment and ask them to discuss some of the most pressing educational issues affecting their work?

The Concord Consortium did just that in the 1997 Teachers Learning Conference (TLC), an intensive, graduate-level NetCourse. TLC is designed to give Virtual High School teachers the skills to create high-quality, content-rich courses delivered over the Internet. The TLC online discussion was thoughtful and candid, their insights provocative.

Early on, TLC faculty asked the VHS participants to read articles about educational reform, and to consider how VHS and its NetCourses fit into reform movements. This question provoked surprisingly passionate written responses from almost every TLC participant. Their opinions varied, but they had in common strong and personal feelings about the topic of reform.

A number of participants agreed that they had mixed feelings, at best, about educational reform, or at least the term "educational reform," which had negative connotations for many. "I am always ready for something new, but the term 'educational reform' often prompts some cautionary, if whimsical, response when I hear it," stated Jerry Lapiroff, a VHS site coordinator at John F. Kennedy High School in Fremont, California. "We have been taken back and forth and back again since I have been in the classroom, many of us, paradoxically, without changing."

Quite a few participants echoed Lapiroff's sentiments. For many, "educational reform" is a charged expression, and the immediate reaction is negative. Teachers and site coordinators alike contributed pages of postings to the discussions, explaining their frustrations with "endless reform programs" and "reform-of-the-month" packages pushed on them by outsiders, people "not in the trenches." One teacher described such programs as "distracting, cynicism-causing." Ruth Adams, a VHS teacher in Shrewsbury High School at Shrewsbury, Massachusetts, expressed her frustration with "legislators and independent educational consultants who more often are either interested in boosting their popularity or selling their products and services than they are about what makes for effective learning."

What do VHS teachers think?

Several teachers recalled a long list of reform movements they'd seen come and go, each one seeking to "replace rather than enhance" established methods of learning. None of them were thoroughly looked at, analyzed, or implemented afterwards. One teacher described more than twelve reform packages he'd experienced in the last eight years. "Every year," he wrote, "it is a new panacea!"

Participants reacted against the idea that any one reform philosophy held the answer to all of a school's problems and challenges. While many teachers continue to search for the best combination of old and new learning methods in their daily practice, they felt that oftentimes reformers try to completely displace a method, without considering teacher input regarding what works and what doesn't. As Marlborough (MA) High School VHS teacher Steve Johnson put it, "Every learning technique has its appropriate application, and an effective teacher draws upon all of them."

As a result, many VHS teachers and site coordinators reacted to any mention of educational reform with skepticism, despite the fact that they were not at all opposed to changes in education per se. In fact, they held very clear, formed ideas on what reform ideally should mean.

Although one teacher felt it was essential that VHS be free from any association with a reform effort, others felt that, by its very nature, VHS would become part of educational reform, which would lead to

LINKS ON THIS PAGE

Teachers Learning Conference—vhs.concord.org / tlc / 1998 /
Marlborough High School—www.marlborough.k12.ma.us
Shrewsbury High School—www.ci.shrewsbury.ma.us / Sps / Schools / High / HSindex.html
Virtual High School—vhs.concord.org
John F. Kennedy High School—www.wccusd.k12.ca.us / kennedy / kenhp / kenhp.htm

important changes in the way teachers teach and students learn. Some of these teachers emphasized that the VHS experience would not replace current learning styles, but instead would "further enhance student involvement in the learning process."

Louine Teague, a VHS teacher in Lumberton, North Carolina, wrote: "I don't think we should become so intent on reform that we forget what we are about. . . . When I realized that I was going to be able to teach geometry as I wanted instead of sticking to a formal curriculum as prescribed and TESTED by the state, it was a dream come true and I felt that I WAS a part of the reform movement in education."

Steve Johnson felt that VHS served as another learning option open to students. As such, it would allow them to be "more personally involved in their academic experience, more reflective in thought and script, more comfortable with educational technology, and more appreciative of global perspectives via network learning."

Other teachers added that NetCourses would allow them to create a more democratic and customized environment, a place where students wouldn't be judged by outside appearances, and in which they'd have time to discover and formulate their own thoughts in response to asynchronous discussion questions. "The issues that are shaping the design of VHS are those same issues you see in the literature on reform," wrote Pam Martin, an Allen, Texas, VHS teacher at Allen High School. "The ability to allow for independent as well as collaborative inquiry is not unique to a course online, but an online course is a natural venue."

While VHS teachers initially reacted negatively when "educational reform" was mentioned, they saw their own efforts and participation in VHS as a way to bring about changes in education, call it reform or not. What the teachers and site coordinators really wanted was a reform movement that allowed them to combine the best of all learning practices, including collaborative-style NetCourses. "The major premise . . . is that students should be given opportunities to learn in different ways," wrote Pam Martin.

These teachers want educational change that comes from their own extensive teaching experiences, and they're willing to take risks, consider new ideas, and learn to use new technologies to accomplish that. Louine Teague explained, "I want to try to plan activities that would lead students to question what they observe—to question whether certain observations were always true and 'discover' the facts."

We all hope that VHS is such a program. As Stanley Oberg, an Acalanes High School teacher in LaFayette, California, said, "Maybe the VHS project will be a way of helping all of us find ways to help our students to become truly active learners." @

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Who's Right?

Secretary Riley invites students to debate human rights online

by Lee McDavid

If you think high school students are using the Internet just to track down their favorite touring band members, think again. During one recent online chat, they were passionately discussing school prayer, international dictatorships, the right to bear arms, the Declaration of Independence, slavery, the Berlin Wall and much more.

What prompted this outpouring of philosophical ideas from hundreds of students across the country?

"This idea began because it was our goal to pay homage to the signing of the Universal Declaration of Human Rights" fifty years ago, explained Erica Lepping at the U.S. Department of Education. As part of a White House commemoration of that signing, Secretary of Education Richard Riley facilitated his first online chat with students from eleven urban and rural schools nationwide.

"This is really the first time that the Secretary of Education has ever done this," explained Lepping.

Several Virtual High School students from Miramonte High School in California were part of the discussion, which surprised the Secretary with its maturity and honesty.

(continued on page 13)

LINKS ON THIS PAGE

Virtual High School—vhs.concord.org
Miramonte High School—intergate.cccoe.k12.ca.us / miramnte / vhs / virtual.html
Allen High School—aisd2.allen.k12.tx.us / ahs.nsf
U.S. Department of Education—www.ed.gov
Acalanes High School—www.acalanes.k12.ca.us / acahigh.htm
Universal Declaration of Human Rights—www.udhr50.org

“Minds-On” Inquiry with GenScope

Teaching Students to Think Like Scientists

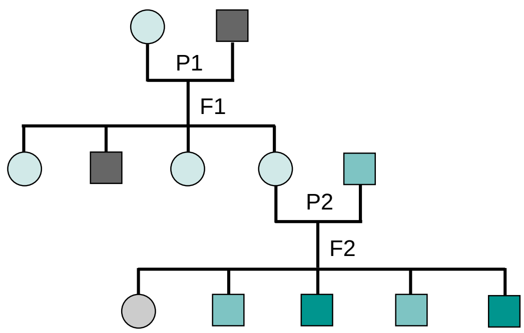
by Mary Ann Christie

The Concord Consortium is committed to figuring out what works—and what doesn’t—in educational technology. A large piece of our commitment is invested in research and development efforts that specifically explore new paradigms for educational technology. GenScope offers such a paradigm in the form of a computer-based manipulative (CBM)—an emerging genre of educational technology that uses the computer to bridge the gap between information (facts and figures) and knowledge (the mental associations we construct to explain the facts).

The National Science Education Standards place considerable emphasis on inquiry as a foundation for critical thinking, analytic reasoning, and deep understanding of scientific phenomena. In effect, the standards call for all students to learn to “think like scientists.” Through the development of new technology, funded by the National Science Foundation, the GenScope team is working to provide teachers and learners with an innovative learning environment designed to move them toward this national goal.

Why is it Hard for Students to Think Like Scientists?

Consider how professional scientists think and learn. In the domain of genetics, for instance, scientists are often called upon to solve problems by inductive, effect-to-cause reasoning. In contrast, the traditional textbook approach to science learning fills students with information and challenges them to reason deductively from cause-to-effect. Moreover, the cognitive processes involved in reading a textbook go far beyond basic word recognition skills, and require a pre-existing conceptual framework as a basis for understanding. By definition, novice students do not come to class fully equipped with such a conceptual framework. Thus,



it is very difficult for them to learn to think like scientists—for example, to understand the phenomena they observe as outcomes of underlying processes that are not directly perceptible. Without the scaffolding that allows learners to turn raw information into knowledge, the information they acquire is often meaningless to them.

Why Technology?

Our goal is to exploit technology in innovative ways that will change the nature of science education by creating a different kind of learning environment. GenScope was conceived as an alternative to text-based instruction—one that emulates the way scientists themselves learn through active inquiry, inductive thinking, and model-based reasoning. It offers students a scaffold for building a conceptual framework which, we hope, will support their science learning in unique ways.

GenScope introduces genetic phenomena in the context of a fictitious species: dragons. These appear in cartoon-like shapes on the screen, but their underlying genetic structure is quite realistic and illustrative of topics from Mendel’s Laws to genetic drift in populations. The computer seamlessly links six levels of description (population, pedigree, organism, cell, chromosome, DNA) and enables students to investigate each in the context of all the others. This multi-level design makes it easy to explore connections between levels and across topics, and guides students to an understanding of the deep connections between domains (e.g., molecular biology and evolution) that are traditionally taught as though they were unrelated.

GenScope in the Classroom

The Concord Consortium shares with the National Standards a commitment to the ideal that all students can understand and appreciate science if given the opportunity. For the past two years, we have explored the ways in which GenScope can provide such an opportunity. Most of our work has been in urban classrooms where students are traditionally underrepresented in science. While it has proven elusive to demonstrate statistically that the students who use GenScope fare better on test outcomes than comparison groups, we have observed some striking transformations in classroom culture.

LINKS ON THIS PAGE
GenScope—genscope.concord.org
National Science Foundation—www.nsf.gov
National Science Education Standards—www.nap.edu / readingroom / books / nses / html / overview.html#organization

The majority of students in GenScope classes become active learners through self-regulated problem-solving at the computer, rather than passive learners of teacher-directed instruction. In specific instances students who had never interacted with the teacher or with other students have begun to ask scientific content questions and become more involved in the class. Teachers, too, have reported a change in their role, from "dispenser of knowledge" to coach, as well as an increased cohesiveness in the class as a whole—changes that persisted months after the GenScope experiment had ended. "Exit interviews" done with students after our intervention coincide with our interpretations of their experience.

What's Next in '98?

This year we are working hard to achieve several goals:

- We plan to integrate real-world content into GenScope, for example in the form of videos depicting families facing genetic diseases or other problems.
- We will scaffold our curricular activities on the computer by providing a sequence of reflective questions for students to think about as their understanding deepens.
- We are cataloging our classroom data in the form of annotated video clips which we will disseminate to teachers and researchers over the World Wide Web.
- We are collaborating with other Concord Consortium projects, such as INTEC, by making our software available to them and helping them to create accompanying materials.
- Next summer we will run workshops in Boston and Concord to help teachers learn to use GenScope to stimulate scientific inquiry in the classrooms of the future. @

Mary Ann Christie does research and evaluation for GenScope and The Concord Consortium.

Who's Right?

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At each school, between ten and 80 students gathered to give online comments, which were entered by designated student typists sitting at computers.

"You never know how kids will react," said Cheryl Davis, the VHS teacher at Miramonte. Her students were familiar with online chats and knew it could get a bit chaotic at times. But according to Lepping, the Secretary was "thrilled" at being able to talk with so many students from so many locations at one time.

Teachers had the opportunity to prepare their students for the online discussion using a curriculum developed by Mary Beth Belgen, National Teacher of the Year and Teacher-in-Residence at the Department of Education. But for students, the eye-opening realization that their peers hold a wide variety of opinions was an important demonstration of the Declartion itself, which states, "Everyone has the right to freedom of opinion and expression." @

Lee McDavid is the managing editor of @CONCORD.

I used to think that genetics was somethin' that was . . . boring—somethin' that I wouldn't be interested in—somethin' that I would never have 'till like I'm old or somethin'. But once I got it . . . it had influence cause I thought you know . . . it was somethin' good . . . and I have to learn you know? if you wanna have a career.

FRESHMAN STUDENT

Other classes are boring. No fun. All we do is work, work, work. They don't try to make it interesting or nothin'. Here we had time, we could talk about it, yet we were still learnin'. We had class discussions. Other classes they just sit there and teach....It's aggravatin'!

FRESHMAN STUDENT

I like the genetics better because it was working on the computers. But now we're back in books it's like I hate—I like readin' books but them books are just boring. They're boring! . . . Could I go back down to the computer room?

FRESHMAN STUDENT

LINKS ON THIS PAGE

INTEC—www.concord.org / intec

Online Comments—quest.arc.nasa.gov / chat / prj_ltc / doe / observe.cgi

Knowledge Society
continued from page 2

mation technologies. Technology doesn't obviate the need for intellectual skills—it increases it.

Real understanding of traditional content will be increasingly important in the Knowledge Society because the generalist of the future needs to be able to apply knowledge from many fields. For example, an understanding of algebra is essential when using spreadsheets for planning. (See "Monday's Lesson" on page 8.) The same mental processes that allow one to generalize a series of instances into an algebraic equation are needed to understand how to correctly replicate a spreadsheet cell down a column. One could endlessly teach students spreadsheet mechanics without giving them the skills to use a spreadsheet to make an original projection. Those skills are based on the idea of variable and function, which comes—or should come—directly from algebra. We must expand our concept of algebra slightly to integrate technology into the teaching of critical algebraic ideas within different contexts.

Another example comes from writing. Modern word processors permit an outline view of a file. The easy movement of sections and restructuring of the outline allows one to think in new ways about the structure and logic of an essay. Again, we could teach the outline functions and neglect giving students the ability to use this tool to solve their communications needs. What's needed to use these tools effectively is found in traditional literature and writing courses. The primary intellectual goals of these courses do not need to be changed, but they do need to be updated to include the ability to think with new technologies.

The ability of information technologies to transform, enhance, combine, and transmit all kinds of media will lead to a flowering of the liberal arts. Already we are witnessing a shortage of creative artists who are comfortable with technology. Skills in design, writing, drawing, and videography are just as important as algebra and science. The nearer the Knowledge Society worker is to the Renaissance ideal, the more satisfaction and employability he or she will enjoy, provided that this ideal is supported by a facility with technology.

While this analysis emphasizes the importance of traditional content, it doesn't support the new back-to-basics movement. Alarmed by students who don't know their multiplication tables, some parents are mistakenly lashing out against the entire educational reform movement.

Taken as a whole, the reform movement is moving in the right direction; it emphasizes understanding and application, not just rote and memorization. Increasing student understanding of key concepts will, of necessity, result in dropping many concepts that are now addressed only superficially. Some reform implementations are terrible, however, because they lack important substance and are simply poor education. These implementations must be fixed. But we should guard against abandoning the entire movement just because of some unfortunate examples. The trick is to strike the right balance and ensure that students can master and utilize core concepts.

What is dismaying about the educational reform movement is its lack of emphasis on the integration of technology. There are many reasons for this omission: too much focus on teaching the technology instead of thinking with it; teachers—and their teachers at schools of education—often resist technology; new curricula often avoid developing technology because making it a requirement would limit implementation; those concerned with education of the poor worry about equity in access to technology. These are not adequate explanations, though, for shortchanging an entire generation of students who will need to function in the Knowledge Society.

The educational needs of the Knowledge Society include familiar core content integrated with technology. The goal of learning the core content must be to appropriate it and transform it for one's own use. Increasingly, information technologies will be the instruments with which we all make these transformations.

It is urgent that we create the kind of education that can reach these goals. @

Robert Tinker is President of The Concord Consortium.

Perspective

ReCET Education

by Robert Tinker

> **We have to ask ourselves what technology has to offer education and then design specifically for those needs.**

The continuing trend toward ever more powerful technology is counterproductive for much of education. When microcomputer chips grew too complex, the solution was RISC, or Reduced Instruction Set Computers. What education needs is the comparable solution: Reduced Complexity Educational Technology—ReCET (pronounced RE-set).

I love my new portable computer, one of the most powerful now produced. I am connected to a network with sophisticated servers and high-speed Internet access. These technologies greatly increase my productivity, connection to colleagues, access to ideas and collaborations, and research ability. I wish every student in the world could have the same resources. With universal access to these tools we could revolutionize education, teaching more sooner in collaborative, technology-rich environments that mirror the workplace of the future.

But the technological resources I use cost between one and two times the amount spent in a year, on average, for the education of each U.S. pre-college student, and more than ten times the annual average spent on students in developing countries. Much as we wish it were otherwise, the kinds of resources I use are not going to be universally available in education anytime soon.

We need to rethink educational technology. The question has been “How do we get current technologies into schools?” Current technologies have been designed primarily by technology buffs for their counterparts in business. We have to ask ourselves what technology has to offer education and then design specifically for those needs.

Most microcomputers are designed to do everything. A professional is only going to buy one computer, so it better support all the major applications as well as a huge range of specialized ones. The computer may be a word processor one minute, a grapher next, and then a Web browser. It must support floppies, CDs, sound, printers, monitors, a modem, Ethernet, expansion buses, and more. Since it takes my full attention, it better be fast—I cannot afford to wait ten seconds to load a file or connect to the Internet. The current generation of computers can do all of these things, but such flexibility and performance come at a cost. Not only are the hardware needs unimaginably large, it takes time to learn how to use all the resources and navigate through all the possibilities.

Educational needs are different. In a geometry class, each student needs a dynamic geometry application, but can survive without a word processor. Students in a science class need access to probeware, but they can survive without a timeline generator. A student who needs to browse the Internet can go to the library and use a specialized inexpensive browser. Imagine a school filled with small computer-like devices specialized for different tasks and subjects: ReCET.

Because they are specialized, these devices can be cheap and easy to use, and cost much less than equipping each student with today’s general purpose computer. ReCET could bring to all courses the kind of revolution that the graphing calculator has caused in some math courses. There could be as many ReCET devices as there are students—achieving the dream of one computer per child at a fraction of the current cost. @

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Concord Concortium (CC) Services

Technology has become the focus of classrooms throughout the world. What is the appropriate use of technology in education? Can the power of technology be harnessed to improve learning and teaching? How can technology be used to offer greater educational opportunities in your community? In the past two years, the Concord Consortium has become a leading advisor to schools, corporations, governments, nonprofits and other organizations and groups on technology for learning. As a result of this interest, we have developed CC Services, an arm of the Concord Consortium which offers a variety of fee-based services.

CC Services can help you:

- Plan for appropriate technology or a virtual learning environment in schools
- Develop a NetCourse or group of NetCourses for your high school
- Design and evaluate distributed learning environments
- Use Apple's eMate™ in an elementary or middle school classroom
- Use probeware in a science classroom
- Host a week-long summer science workshop using probeware technology
- Create virtual high school cooperatives

We can also tailor our skills to your needs.

Our experienced staff is available for public addresses on the following topics:

- NetCourses: Implications for Teaching and Learning
- Mobile Computing: Small, Inexpensive Technologies Will Revolutionize Education
- Using Technology to Teach Sustainability
- Designing Computer Models for Science Teaching
- International Networking: Opportunities for International Collaborations
- New Approaches to Modeling in Education

If you would like to know more about CC Services, please contact us for more detailed information.

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