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Technology – Changing the Way We Teach and Learn

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Technology and Education: New Wine in New Bottles

Choosing Pasts and Imagining Educational Futures

Luyen Chou, Robert McClintock, Frank Moretti, Don H. Nix

The shaping of a future for education depends on the choice of a past. How far one looks forward is functionally related to how far one chooses to look back. For instance, if the inclination is to view historical context as limited by the local history of a specific school, that history will constrain visions of future developments. For example, one might prognosticate about the potential evolution of governance structure, or the need to balance a specific heritage with the needs of a changed constituency and so on. Alternatively, to choose as an orienting past the American educational tradition is to find oneself reflecting on the virtues and vices of the classical canon, multicultural education, the resuscitation of science education in the interest of a failing economy, or the role of the school in addressing issues of social justice and so on. Of course, the former set of concerns related to institutional history are not incompatible with the latter related to national history. For example, the national concern with a multicultural curriculum as an alternative to the canonical curriculum might have its local reflection in the tension some institutions feel between a progressive heritage and a significant conservative constituency.

One might choose to cast one's net even more widely, however, by seeing one's school as an expression of the history of modern schools which have arguably been more the same than different since the sixteenth century regardless of national differences. Casting a vision of the future in this historical context requires the identification of the fundamental building blocks of schools *qua* school - that is, the constituent elements of this institution as was shaped in modernity.

Putting aside for the moment the specifics regarding the definition of space and time, the structure of knowledge, approach to motivation and the shape of the teaching profession, it will be argued that the reason for the endurance of this hallowed institution with all its specificity is the stability of its core tool, the keystone of the system - the printed textbook. It is further argued that the medium of print, so long as our almost exclusive means for preserving knowledge, has yielded significant ground to the remarkable storage and retrieval capacities of the computer; and that, further, this loosening of the keystone of the modern educational past allows us to glimpse, and demands that we define, a new educational future no longer constrained and shaped by the exigencies of print/textbook-based education.

The Modern School: The Past

The Structure of Time and Space

Children are grouped by age and each group has a specific space called a classroom. The groups are collected together in one larger space usually called a school building or house. The classrooms themselves are arranged to accommodate twenty to forty children so that they can simultaneously attend to one adult - the instructor. The standard unit of time is an instructional period which is long enough to accommodate a lesson. The lesson is a quantity of information pertaining to a particular realm of knowledge demarcated by the divisions imposed on that area of study by the separate units of a textbook. Instructional periods are arranged in sequences which define the week, the month, the year.

The Structure of Knowledge and Culture

The legacy of the ancient pedagogues, the fragmentation and division of study into the disciplines of the trivium and quadrivium, was complemented by the moderns' further division of each field into the compact lessons and exercises of the teacher's most important tool - the textbook. This standardization facilitated large group instruction and allowed for the comparative evaluation of students, essential to the school's effort to meet its responsibility for the discovery and allocation of the society's intellectual resources. Reliance on the textbook also meant reliance on the built-in educational strategies so closely joined to the information of each lesson. Because textbooks were scripted so thoroughly, it was possible for a teacher to gain significant comfort with each repetition as responses and possibilities became gradually more predictable.

The Structure of Motivation

The modern classroom provided unique motivational opportunities. Relying on the natural anxiety of the young when subjected to judgement and their equally natural propensity to measure worth through comparison, schools were able to use the common playing field of the textbook, yoked to an objectively established and highly calibrated system of evaluation, to inspire Homeric academic efforts. Public honors, social access and economic success became linked in direct ways with school achievement. In fact, in many states, the practice of justice became inexorably linked to the ostensible fairness of a system in which educational opportunity was equally shared.

The Structure of the Teaching Profession

Entering the teaching profession is most challenging in the early moments when one is unacquainted with what lies ahead. To have mastered the role of student in a school does not lead naturally to an easy execution of the role of teacher. Indeed, new teachers often experience their students as unpredictable; many wonder if they will ever be able to gain a feeling of control over the classroom. Soon, however, after a few years of stumbling they gain a mastery of the textbooks and their associated pedagogical devices. They begin to see a repetitive pattern in the way that students tend to respond to the certain problems and issues and, most importantly, they begin to remember which of their responses were effective in which contexts. The key to their success is confinement. They must learn within the already determined environment of the textbook to focus student attention on the key issues which in linked sequence provide the essence of a

The postmodern school with its emphasis on student inquiry will introduce the element of unpredictability into daily discourse and disturb any possibility of the routinization of the educational discourse.

stage of the mastery of a discipline. This isolation and clear pedagogical linking of the important stuff also provides the instructor with a defensible matrix of expectations against which fair evaluation can take place. Essential to the teacher, and somewhat available in the intellectual structure of the textbook, is a refined developmental sense of what is appropriate at which age level. Given the body of material a teacher must cover, time demands that repetition be eliminated and that only those things which are age appropriate, no more and no less, be the stuff of each year's work. The teacher's willingness to commit himself to being part of a team by working within the specific segment of the curricular pie for which he is responsible is a significant sign of professional maturity. To know the sequences of instruction and to know his place in them increases the degree of predictability of each day and hence adds significantly to the ease and comfort of professional life.

The Structure of Ethics in the School

The school is an elaborate social and cultural apparatus. Within its carefully defined structures are manifold opportunities for character building and the informing of the conscience with the appropriate standards of conduct of a citizen and ethical individual. With the school's broad range of daily transactions revolving around winning merit in a competitive environment governed by clear rules, students are afforded the opportunity to learn dedication to a task, self-discipline within a constraining and demanding system, and honesty and fairness within a community. The most remarkable dimension of this aspect of school life lies in its economy. For the school to function as an ethical training ground it requires only that the adults in charge be aware that each transaction or behavior of a student must be viewed from this second less overt perspective. Many teachers view this dimension of their work as so central that everything else becomes subordinate to it. The classroom becomes less a matter of instruction and inquiry and more a constant tuition in the appropriate behavior of people in groups.

The Postmodern School: New Wine in New Bottles

The question the panel will address is how each of the components of the school of the past will change with the new technology.

The Teaching Profession

Virgil's greatness as a guide and teacher for Dante rested in his understanding that his student must experience, either directly or vicariously, all the possibilities of the human soul before discussion would be of value. Accordingly, Virgil seldom offered tuition but most often responded to questions which emerged from the intense experiences of traveling the underworld. The postmodern school with its emphasis on student inquiry will introduce the element of unpredictability into daily discourse and disturb any possibility of the routinization of the educational discourse. Responding constantly to questions emerging from students' experience, teachers will re-assume the Socratic mantle and reverse the progressive de-skilling the profession has undergone since the Industrial Revolution.

Ethics

As we have depicted the ethical conversation in schools it focuses often on socializing the young to behaviors adults have deemed needed for a successfully functioning society. If one adds to this the additional voices which urge self-understanding, free inquiry, and often a humanist ethic staunchly opposed to the competitive forces which shape the society, then one hardly wonders at the confusion of the young who learn only the lesson that the adult world thrives on contradiction and a self-serving hypocrisy. Consider the possibility of whether the dismantling of the competitive apparatus of the school and the establishment of the faculty in the position of respondents would not also eliminate much of the contradiction in the public conversation and in turn reduce the number of voices needed to be reconciled by the students.

Time and Space

The exigency of the modern school, that tuition requires a simultaneity of time and place, will not be a restraining structure of the postmodern school. Through the use of advanced systems of electronic mail students can log queries addressed to their teachers or classmates and, then, check for their answers when they can. This exchange is of course not constrained by geography. Questions can be logged from either within the school through a network or from without via modem. The same technology facilitates scheduling live exchanges. Without the tyranny of the single focus of the textbook as the information core of the process, one could imagine in a networked computer environment attentional foci changing as the teacher and students shift from attending to a large screen suitable for a hundred to working in small groups around workstations to individuals pursuing research on notebook computers linked to a server by a radio coupling. This

The learning environment will be composed of students seeking to pursue individual questions and then coming together to coordinate their results.

requires a flexibility in the learning environment - walls which are soundproof and move, computer stations which are comfortable for four but recede when a group of the whole is formed, work surfaces which are suitable for notebooks but disappear when necessary.

Motivation

The information logistics of the curriculum, the quantity and quality available without travail, decrease or increase the capacity of the curriculum to act as a competitive game-board. In the modern school each student focuses as much on others as on the work at hand in order to catch a glimpse of where colleagues are in the race to master the same information. In the postmodern school the information resources will be expanded and the points of departure multiplied to a degree that each student will travel a path distinctly her own, albeit within the orbit of a single question/area of investigation. The learning environment will be composed of students seeking to pursue individual questions and then coming together to coordinate their results. Cooperation will follow the natural need to understand. When a students travel individual paths within a single complex and multidimensional subject area, they will, out of their own deep sense of insufficiency, seek to complement their own work with that of others.

Knowledge

The sequential textbook locks students into a journey which deems it inappropriate to either go back or forward in the sequence if it distracts them from the matters at hand dictated by this year's curriculum outline. The concept and practice of graded classes follows this division of knowledge. Imagine what would happen to graded classes if the computers contained within them a comprehensive system of information, multimedia in character and accessible to children from the fourth grade on. Try to predict what would happen or where a student would choose to go who begins with a document on the Civil Rights Movement and serendipitously explores the related hypermedia links. The notion of sequence and the sacrosanct attitude towards developmentally appropriate material would probably collapse and be revealed as the significant prejudices of the print world. Further, the modern prejudice in favor of verbalization as the preferred mode of discourse will yield to the resurgent power of visualization in the postmodern world. The former's near hegemony will diminish and a new intelligence similar to the state of knowledge in the pre-print world will emerge.

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K-6 Students' Use of the Web: Working With On-Line Guides or Experts

Kim Rose, Apple Computer

How can we utilize the Web* and its users for K-6** stu dent access as amplifiers to learning and enhance their daily classroom experience? How can we promote change to "School" as we know it to extend beyond the classroom walls and engage students with adults, especially in those areas requiring specialized expertise? What have pilot telecommunications programs taught us about the use of this technology so that we may broaden the learning experience? How can Elementary schools be afforded easy-to-use, easy-to-navigate access to the Web? How can we recruit specialized individuals to volunteer their time to correspond with students to offer them insights, opinions and ideas and motivate them toward continued questioning and learning?

Models for learning are changing.

Environments for learning are changing - or perhaps not. We've known for a long time that often one's best learning takes place beyond the Classroom - in homes, theaters, outdoors, or via the telephone. The tools our information age is offering can help us to exploit the idea of learning beyond traditional classroom walls at a time where it is very much needed. It is up to us to decide how to use the technology - Neil Postman reminds us that it is not the technology that can improve our learning, but the media we create from that technology. What can we make of these tools to benefit our children? What kinds of "programming" shall we develop for this new media to amplify learning?

Teaching our children how to think, problem solve and be productive, creative adults can no longer be the responsibility of schools and classroom teachers alone. Along with parents (many of whom need to be reminded that

**The Web, or World Wide Web, is a resource tool on the Internet. The Web allows users to move rapidly between different multi-media documents at different sites around the world.*

***In the United States the majority of children attend three schools before entering an institution of higher education: Elementary school, which begins with Kindergarten and goes through Grade 6 [K-6]. Generally, a child is 5 years old upon entering Elementary School. Middle School continues for children grades 7 though 9; and finally High School for grades 10-12. Many children also attend Pre-School before entering Kindergarten.*

their child's education is not solely the responsibility of the school they send their child to attend daily) I suggest it is also the responsibility of the larger community to assist in developing society's children into thinking adults who are proud to be life long learners.

The Web offers us a way to do this

We know how astounding the growth of users of the Internet has been. Internet users represent all ages, cultures, and ways of thinking. Work paradigms are shifting. More of us are working from our homes. School paradigms are going to shift as well. Home schooling is becoming ever more popular as problems continue in our Schools. K-6 educators became generalists because that's what the system asked them to do. More and more demands have been placed on these professionals due to the path our society has taken. Teachers too often need to also be disciplinarians, and sociologists, dealing with children from split homes, dysfunctional homes, or homes where both parents work 12 or 14 hours a day. It's time for professionals outside of our official educational institutions to participate in the teaching of our next generation of adults.

We need to examine experimental programs that team students and adults outside of the classroom, and from them, formulate highly accessible tools and programs which can work alongside and benefit our current educational system.

Pilot Programs

Educational programs using new technologies have been experimenting with the notion of having students correspond via email with "experts" as an adjunct to their classroom experience. I will briefly discuss four projects in which Apple Computer researchers have been involved. From these programs, I suggest we can take what has worked best and develop new programs which work even better.

AGE

Apple Computer developed a research and development project called AGE - APPLE GLOBAL EDUCATION in 1987. AGE was one of the first programs designed to connect teachers and students world-wide. Since then, AGE has connected 300-400 schools in 32 nations, their teachers and students. AGE is a proven global education network of "master" teachers. AGE is teacher-designed, student-centered, and teacher-directed.

One of the central issues in AGE is curriculum. Traditionally, curriculum is the knowledge organized and packaged into forms suitable for instruction in schools. That means, textbooks, workbooks, lesson plans, "scope and sequence", and the other forms of instruction "containerized" for delivery before the student even enters the classroom. AGE projects touch every discipline: Literature, History, Science, Math, Arts, Technology and Computers, Journalism and DeskTop publishing. In addition, AGE offers grant guidelines, and upcoming conference information for teachers and administrators.

Primarily, AGE has been a good resource for teachers. It broke the isolation of the single classroom. No longer limited by the materials in one room or even one school, teachers could draw upon new colleagues and new resources...around the world. Schools could learn from and grow from one another. Resources could be quickly and easily shared.

AGE has most benefited students by affording them the oppor-

Teaching our children how to think, problem solve and be productive, creative adults can no longer be the responsibility of schools and classroom teachers alone. It is also the responsibility of parents and the large community.

tunity to establish email pen pals and exchange cultural information. However, there is not much opportunity for student learning beyond this possibility. What is also unfortunate is that this network is only available to those students and teachers subscribing to Apple's AppleLink network; non-AppleLink users cannot access AGE.

Growing Connections/Life Lab Science

Life Lab is an exciting hands-on science program with a "Living Laboratory" approach to elementary science education. Students utilize indoor and/or outdoor garden laboratories as the context for the meaningful study of earth, life, and physical science. In a cooperative learning environment, students experiment, investigate, collect, record, and analyze data, in order to discuss, problem solve, and draw conclusions. All lessons are easily integrated in a most relevant manner into all areas of the curriculum.

The Life Lab Science program began in 1978 when a teacher from a small school in Santa Cruz, California, gathered a group of students together to garden. From this adventure and the field testing of the ideas from other teachers and students evolved the first published curriculum, "The Growing Classroom" (Addison-Wesley, 1990). Continued refinement, through field testing, further research and lesson development, and input from more teachers and students, resulted in a comprehensive, thematic science program for each grade level: Life Lab Science, K-5 (Video Discovery, 1993).

The Life Lab Science Program supports "Growing Connections," an on-line information exchange between students and teachers on AppleLink who share science project data and findings. Growing Connections was started as a collaborative effort between the Life Lab Science program staff and Apple Computer's Learning Concepts Group researchers.

Since 1990, twelve Life Lab Schools in California and Florida piloted and have sustained Growing Connections. Projects have been set up using Life Lab lessons in which enthusiastic teachers and students exchange information electronically about experiments on radish, peanut, and fava bean growth, bird watching, and building compost piles. Exchanging weather data, curriculum integration ideas, and pen pal exchanges, are also part of this successful and exciting project.

Growing Connections also offers assistance from a volunteer "scientist-on-line" - Joe Jordan from NASA Ames, based in California. This component of the Growing Connections has been one its the most valuable. Here are some comments from Joe regarding his participation in the project:

> "Participating as "scientist-on-line" in the Growing Connections computer-telecommunications network has been fun. Although my professional work is atmospheric sciences research at NASA (Ames), education has long been something I consider of paramount importance to the world's future, and teaching is really my main passion and talent, probably. So I've appreciated the opportunity to be of service, not only to the students, but also to teachers. This network enables me to keep in touch with the interests and curiosities of school kids, and occasional announcements I'd broadcast (often about events in the sky) seemed to generate enthusiasm. One of my favorite questions received was, "Are there rivers in outer space?" - (to which I responded that there possibly were once rivers of liquid water on Mars, and there certainly must be many in other solar systems ... but maybe that's not what they had in mind!). When "answering" questions, I usually try to either guide the students in their own investigations leading to answers, or to give them a bunch more information than they were specifically asking for, in hopes of stimulating further questions."

Four components are key to the success of the Growing Connections project: The small base of users offers an area which is very easy to navigate. The participants need not embark into a deep, dark hierarchy of files with hundreds of entries to obtain the information they seek. In addition, all of the information available is embedded in the same context. The umbrella of the Life Lab Science program and connected themes keeps things compact and relevant. Joe's adjunct offering of insights and opinions enhances what the teachers can offer the students as well as giving the students an additional resource and point of view. Finally, Joe's attitude of having "the opportunity to be of service" and knowing the value of keeping in touch with the interest and curiosities of school kids is one that should be shared and emulated by more adults in our society.

Seeing the value in Growing Connections' offering of a "scientist-on-line" sparked the addition of Expert People Resources for Educators to Apple Computer's K-12 Educator's Resource area on

AppleLink.

Expert People Resources for Educators

This resource offers guest experts from the fields of science, social studies, math, educational technology, and educational restructuring and change. Each expert is featured in a separate folder within the area. In each folder the user will find informational material, as well as a sub-folder where they can post questions and comments to the expert.

This 1992 addition to AppleLink offers only 5 experts - one of whom is Joe Jordan from NASA Ames. Unfortunately, this resource does not appear to get much use. Several of the participant's folders have not be added to for several months.

I believe there are several reasons for this: Lack of publicity, and therefore, knowledge that the area even exists. The resource area is too buried in the AppleLink hierarchy for people to find. The people represent areas of random expertise; subjects range from information on how to establish your own bulletin board to how to maintaining your computer hardware. The content is not embedded in anything as is Joe's participation in the Life Lab Science Growing Connections project. These experts are detached and floating in an area of cyberspace - they need to be grounded in something with more context.

Ross School and the Exploratorium

In the spring of 1993, Kristina Woolsey, one of Apple's Distinguished Scientists, oversaw a team from San Francisco's Exploratorium to work on a multimedia bulletin board project. The intent was to explore how networked multimedia email systems could be designed for learning. A fourth grade class studying weather was the focus of the experiment. The children had many questions - why are clouds darker at the bottom than the top? They wondered if the color of the grass had anything to do with the weather. Why if it rained all day yesterday were there only "two little puddles" at the school today? What causes tornadoes?

With video cameras, computers and Quicktime software, the kids expressed their questions to a group of volunteering scientists at the Exploratorium. Using the same technologies, the scientists offered not only answers, but suggested experiments the students could do themselves to illustrate the scientific phenomenon they were thinking about. The scientists also coached students so they could tie the big ideas together. The experts found the children asking more thoughtful questions as the program went on. The experts elaborated theories, offered new questions and provided additional resources for the class. The kids found that they learned not only more about the scientific phenomenon they were investigating, but also about a range of new things as they used the computers and video cameras.

Establishing a project to connect teachers and experts proved highly beneficial. Many school teachers feel quite uncomfortable with much of the material they are expected to teach their children in the area of science. This scenario enabled the teacher to be more of a facilitator. She could learn along with her children. The science museum served as a critical partner to this program.

The additional tools used in this project can provide an excellent example of how we might take advantage of using multimedia on the Internet to exchange lively data and images thus providing depth to the issues being explored and examined.

Existing Programs

America OnLine (AOL) is another telecommunications service popular with Macintosh users which provides email and other various information services. This service has approached the concept of providing expert help online by offering "Homework Help Drop In" and a "Teacher Pager" device as part of their Academic Assistance Center in the Learning and Reference area. AOL has successfully recruited over 300 volunteer teachers to serve as experts in this area. There are folders within folders within folders on literature, science, math, and history containing hundreds of inquiries and answers on everything from Milton's Paradise Lost to astronomy. Although I know students have much more perserverence in digging than I, this type of system is very difficult to sort through. Thinking of these services as resources for information access and to assist in critical thinking, and not as televisions in which to "channel surf" I seek a model that is less conducive to surfing and more so to spear fishing for a particular species of fish. The other problem I have with this model is that once again, it is the classroom teacher doing all the work. This is another job for the teacher who is already pressed for time and expected to be an expert in all things. I am suggesting we take that load off the Classroom teachers and ask professionals to take responsibility to assist in the education of our children. A nice feature of the "Teacher Pager" device is that once the student has

Teachers need more discourse with other adults outside of their school environments. They need help to become facilitators of learning. Adults in other workplaces and professions also need to be better in touch with today's children.

sent a query, responses come right into their mailbox. There is no need to go back into a bulletin board area to sort through hundreds of other student queries to find responses to your own.

New Programs - The Challenge to define the Media

Apple Computer has recently added its server to the World Wide Web. I propose a project - THE EINSTEIN PROJECT [Expert International Network for Students to Think & Engage in Intellectual Networking] or AGORA [Apple Global Online Resource Arena] to recruit individuals representing various areas of expertise who are willing to serve as experts to the learning community. A database of these individuals would be created and accessible to any user of the Web regardless of what system or software they use to access the server. Anyone seeking information could perform a keyword search and obtain a list of individuals representing their desired area of inquiry. The multimedia database could include a photo and thumbnail biography of the expert. Students would select who they wished to correspond with and do so via direct email via the Internet. Mail would be received directly by the expert. This would eliminate the need to check other programs (i.e., AppleLink, America OnLine, eoWorld, Kids Net, CompuServe, etc.). Any email system used by the expert would work. This would eliminate the problem of sifting and wading through excess irrelevant information for the student to find their particular feedback (as it works with the Teacher Pager device in AOL). It would also be cost effective for the volunteer expert - not requiring them to be a subscriber to any of these services and pay additional online charges for their time on the service.

Networking children and adults would be of great value to us all. Commenting on a teacher's need to keep in touch with other adults, Bertrand Russell said a teacher should not spend more than two hours per day with his students. Teachers need more discourse with other adults outside of their school environments. Teachers need help to become facilitators to learning. Adults in other workplaces and professions also need to be better in touch with today's children enabling them to understand their motivations and curiosities as Joe Jordan reminds us. We need to build online communities where children and adults can engage in thought provoking discourse.

These ideas represent initial thoughts and possibilities for enhancing learning by utilizing the WWW and new technologies. Your ideas would be valued and most welcome. If you would be interested in participating as a volunteer in this project or have comments please contact me.

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The Humanities in Cyberspace

How the Internet is changing Teaching and Scholarship in the Humanities

Charles Deemer

On a winter afternoon in a small eastern Oregon town I'll call Rural, Tom, a high-school junior, boots up his computer. As he waits for the operating system to load, he stares out the window at the snow, piled in drifts after the recent storm, thankful that he doesn't have to go out into the weather to the library, even though he has a research paper to write. It's the same paper, he remembers, that gave his sister, Sue, fits last year.

The assignment is to write an analysis of Arthur Miller's play, "The Crucible," which has been required English class reading for years in Rural (the battered old school texts show it). Last year, by the time Sue got to the school library, and later to the small community library, the few books of commentary on the play were already checked out - if they weren't lost. Like many students before her, she found herself calling everyone she knew to find out who had checked out the precious reference material and what it would take for her to spend an hour with it.

This year Tom begins his research much more leisurely. When the computer is running, he loads a CD-ROM "electronic book" version of "The Crucible" recently released by Penguin, a product that demonstrates the extraordinary way in which technology is changing the way this play and other subjects can be studied. On a snow-bound afternoon in the middle of nowhere, with nothing more than a computer and CD-ROM drive, it's as if Tom suddenly has the resources of a major library right at his fingertips.

Much more than the text of the play is included on the CD-ROM. A coding system called "hypertext" links each part of the script to a vast world of commentary and enrichment, which Tom can access by clicking his computer mouse on appropriate icons and menu items. The result is as dazzling as it is educational and captivating. Click! On the computer screen appear the pages of an open book, the script of the play shown in easy-to-read type. Click! Now a window pops up, in which a video of a London production of the play can be watched, picking up the action at where the "electronic book" is open on the computer screen. Click! In another video, the actors discuss their roles in the play. Click! In still another, Arthur Miller talks about writing the play. These are resources seldom available to anyone, let alone a high school student, but more traditional materials are available as well. For example, Tom can bring up a bibliography of criticism about the play, a breadth of scholarship usually reserved for the better University libraries. Moreover, he can click on items on the list to go directly to the individual articles themselves. Or click to material about the Salem witch trials and the 1950s House Unamerican Activities Committee scare, both important backdrops to the play. All of this is available to Tom in his home on a single CD-ROM. But even more powerful and dynamic is the way education is changing in schools that have access to the Internet, the international network of computer resources. The traditional boundary between urban and rural school districts - giving educational advantages to larger communities with greater budgets, more resources, and a wider variety of cultural activities - is disappearing as the Internet revolutionizes the way the humanities will be taught in the future.

Technology and the Humanities

Teaching and research in the humanities have always responded to changes in technology. As human clans evolved from being strictly oral to being both-oral-and-written communities, the transmission of information - teaching and learning - changed in kind. Over time the Text gained precedence over the Sage (the person who recites the Text), which in turn elevated the cultural importance of keeping the Text in a safe place.

The invention of the printing press made written information - books - easily duplicated and text less sacred. The storage house of knowledge (where the Text is) moved out of the religious santuary and into the private library, which political and cultural changes eventually redefined into the widespread public library of this century. Today the computer creates a dazzling electronic space - cyberspace - within which information is transmitted almost instantly and with almost no regard to boundaries. Nowhere is this profound change in the storage and dissemination of knowledge more impressive than on the Internet's World Wide Web.

Classroom Without Walls

The Internet is a network of networks of global computers that can talk to one another and exchange all kinds of information - from electronic texts of classical literature to current periodicals; from bibliographies to library indices; from formal scholarly papers to personal electronic mail; from text to graphic images, sound and even video.

Most of what the humanities scholar can do in the classroom, the office, or the library can be done more efficiently on the Internet. Computers linked together by the Internet are found in both urban and rural areas - at universities, government agencies, corporations, and private homes. About 20 or 25 million people have access to the Internet, and this figure is growing rapidly.

There are many ways to get around on the Internet, linking from one computer on the network to another, but the fastest growing and most powerful resource tool is called the World Wide Web. Using the same "hypertext" coding principle found on multi-media CD-ROMs, the Web permits rapid movement between different documents at different sites, literally moving the researcher between different libraries around the world in a matter of seconds. For example, a researcher logged onto the Web can immediately move from a document at one location, the University of Maryland, to a corroborating document (or part of a document) elsewhere, say at a company in Sweden, then to a relevant commentary at UCLA, and finally back to the original document - all in a few minutes. The tool making this rapid interaction possible is called hypertext -a nonlinear interactive electronic text that has become the primary language of the Internet and may well become the test of literacy in the twenty-first century.

Jane, a student in a small suburban high school, is assigned a research paper on the history of hypertext and its new applications in hypertext fiction. After connecting to the Internet, Jane instigates a "veronica" search for the word "hypertext." In a matter of seconds, her computer screen shows a list referencing every menu on the Net that mentions "hypertext" (a menu is a "table of contents" at an individual Internet site, telling what is available there and elsewhere and providing the links for accessing the material).

Following electronic links that begin at each menu, Jane is led to relevant documents about hypertext. She learns that hypertext has a very long history. The concept was first presented in a 1945 Atlantic Monthly essay by Vannevar Bush called "As We May Think," which is available in its entirety on the Internet. Jane electronically mails the article to herself so she can read it later. She learns that the guru of hypertext, who coined the term in 1965, is Ted Nelson, whom she locates at the Xanadu Corporation in Australia, where many of Nelson's seminal articles are cited and his current work summarized.

Continuing her global research, Jane finds a wealth of introductory material at CERN, the particle physics supercomputer in Switzerland, including a glossary of hypertext terms and an essay, "What is Hypertext?" She mails both to herself. She finds significant contemporary material at the University of Virginia, downloading essays with titles like "The Rationale of Hypertext" and "Virtual Textuality." At the University of Ottawa Jane finds a journal, The Hypertext Review. At Rice University she finds a "Home Page" (table of contents menu) maintained by a systems programmer (not a literature professor!) that contains links to numerous examples of hypertext fiction on the Internet. Her exploration takes her to the "alt.hypertext" newsgroup, a forum where hypertext experts talk shop, and there she finds Mark Bernstein of Eastgate Systems, the country's leading publisher of serious hypertext fiction. She sends him an e-mail message, asking for an interview. He quickly accepts.

Only half an hour has passed, and Jane has mailed herself relevant documents from sites in Australia, Switzerland, and Canada, as well as from Virginia and Rice Universities. She has also scheduled an interview with one of the country's experts on hypertext fiction and located the guru of hypertext, Ted Nelson. Not a bad half-hour's start on her paper for a student who lives miles from the nearest college library.

Graphics, video and sound are available on the Internet to those with the proper hardware and software to access them. A student of art history can take the Internet's "virtual tour" of the Louvre. A scholar can download sound files from the daily Internet Talk Radio program (patterned after National Public Radio) and listen to a book review or interview over her computer's sound card.

The humanities resources on the Internet are growing rapidly. Project Gutenberg, for example, puts the full text of world literature classics online. Dozens of works are already available - philosophical treatises by Plato and Descartes; novels by Jane Austen, Mark Twain, and Dickens; poetry by Milton and Longfellow; the complete works of Shakespeare - with more texts brought online regularly by this and similar projects.

On the Net, students can join electronic forums and find contemporaries with similar interests, making "virtual classmate" friends around the world. They can practice their foreign language studies with native speakers. Students can even participate as equals in scholarly forums with professors - judged only by the quality of their ideas. (In a New Yorker cartoon, one dog at a computer says to another, "They don't know you're a dog on the Internet.") The classroom that has access to the Internet is a classroom without boundaries.

Distance Learning

Rural communities have the same opportunities as urban ones on the Internet, as long as they have access. Even in areas without nearby colleges, "virtual classrooms" can provide disciplined and accredited course studies. "Distance learning" brings the school to the student, rather than making the student go to the school.

Mike is a recent widower. After retiring, he often thought of going back to college to pursue his lifelong interest in American history. But Mike has to use a wheel chair and isn't very mobile. When a friend tells him about distance learning, which would let him take accredited college courses at home on his computer, Mike decides to look into it.

On the Internet, Mike finds the International Centre for Distance Learning in the United Kingdom. He accesses their central electronic catalogue, which permits him to search for classes. To his astonishment, his first search reveals that there are 7,833 accredited humanities courses offered by computer at colleges and universities throughout the United Kingdom. As he narrows his search to areas that interest him, Mike finds a course called "Origins of the American Revolution," which is taught at a University in New Zealand. He is intrigued by the notion of getting a "foreign" point of view about his own country's origins and electronically sends for additional information. Within a few minutes, he receives an electronic brochure and application by automated return e-mail and decides to enroll.

A surprising number of degrees - including graduate degrees - are available by distance learning. Besides providing a greater choice for students who have difficult access to classrooms, distance learning also offers new and increasing opportunities for teachers.

Cultural Diversity in Cyberspace

The World Wide Web is an international phenomenon. Sometimes American researchers suddenly find themselves facing computer menus in Spanish, French, or Japanese (although an English translation is usually only a keystroke away). This international climate establishes a sense of intellectual community, bringing all the resources of the world into a common cyberspace, suggesting an emerging holistic organization of knowledge.

Vladimir, a Russian immigrant and poet in Portland, has been homesick ever since he arrived. When his new American friend introduces him to the Internet, gaining access at Portland State where he teaches, Vladimir's world changes dramatically. Subscribing to personal access by his PC at home, Vladimir discovers the Window-to-Russia Home Page maintained by the Relcom Corporation in Moscow. Downloading free software to give his computer screen Cyrillic fonts for showing Russian, he is able to access literary archives at Moscow State University. He tours a "virtual art exhibit" at a gallery in Moscow, finding the work of several of his old friends. Linking to the University of Pittsburg, Vladimir finds the "World Wide Web Virtual Library for Russian and Eastern European Studies," an even greater resource of Russian documents. Here he finds numerous files of Russian literature, humor, myth, and music - all in his native language. He learns he can download a weekly digest of articles from Russian periodicals, giving him a way to keep up with intellectual and artistic news from home.

Vladimir also uploads several new poems into archives in Moscow, so that his former readers and colleagues can keep abreast of his recent work, despite the physical distance separating them. For the first time since coming to America, he has the sense of having an audience for his work again.

The Web's Virtual Library provides a starting point for research in all the disciplines of the humanities, providing electronic links from the Library's Home Page to more specialized Home Pages at educational institutions around the world. Using Internet (free) software like Lynx or Mosaic, the Internet researcher can create his own Home Page on the run, a table of contents of those links relevant to individual research.

The Office as Conference Center

Although research by computer is as solitary as traditional library studies, the opportunity for professional networking is one of the more powerful features of the Internet. Forums, newsgroups, and mailing lists are organized by subject matter, from the most esoteric humanities discipline to broad areas of popular interest. Scholars and students can easily and regularly communicate with their colleagues with similar passions.

Indeed, it can be argued that the Internet has revived the lost art of letter writing, which the advent of the telephone almost made extinct. Electronic communication on the Internet is so popular that an active academic mailing list can generate over 100 postings a day. Never has it been so easy to keep abreast of contemporary scholarship in the humanities. Since scholars are already used to networking at regional and national conferences on their specialties, now they simply bring the conference back to the university office, continuing the discussion throughout the year with electronic messages that are received a few seconds after they are sent.

The Amateur Scholar

Students, whether officially enrolled in a course or not, also can participate in most professional academic forums on the Internet, giving rise to a kind of "amateur scholar" who can have a far greater chance of being taken seriously than he or she would in non-electronic forums in academe, which have more restricted access.

Today, students can make their work available to an international professional audience, gaining recognition (or scorn) from the best minds in the field. On the Internet, one's ideas speak for themselves without regard to tenure, publication credits, academic or national affiliation, or professorial demeanor. As a result, the Web is a gold mine of intellectual surprises.

Tyler Jones, a student at Willamette University, has done an impressive amount of research to put together the "Human-Languages Page," which he describes as "bringing together information about the languages of the world." In addition to the expected links to literature, dictionaries, and tutorials in the major languages, this gem of a Home Page links the reader to Bulgarian poetry, the daily news in Danish or Turkish, a Forwiss dictionary, information on the Gaelic language and culture, and a Welsh tutorial.

A Beaverton school teacher, Vince Ruggiano, has authored an "Educational Resources Home Page" that is an excellent starting point for K-12 teachers in the humanities and other disciplines. Links to K-12 schools throughout the world that are hooked up to the Internet are provided (in Oregon, 7,000 to 8,000 students are online this year.)

On the Internet, new resources in the humanities are announced every few weeks on the "What's New" Home Page and keeping up with the new material is an intellectual adventure.

The Fluidity of Knowledge

Boundaries of all kinds disappear on the Internet. As more of the world's intellectual resources become available electronically, it matters less whether schools or scholars are in an urban center or a rural hideaway - as long as they can connect to the Internet. The traditional teacher-student boundary also becomes fuzzy, as exchanges on the Internet focus on written language and the quality of one's ideas, not the accompanying parameters of age, experience, and body language that so often influence our notions of credibility. For example, a few years ago I had a stimulating electronic discussion about drama and playwriting over a period of several months before meeting in person the "colleague" with whom I had been exchanging ideas. He was a high school student, a fact that somehow had never come up, and I could have been his father. Unfortunately, learning about our considerable age difference changed everything, whereas earlier, in our ignorance, we were able to debate ideas as equals. Sadly, we never recaptured that mutual sense of respect and equality. The World Wide Web is perfectly named because it is, in fact, a grand web of resources, holistically connecting much of the world's knowledge and much of the world's culture and making it available to people and places that never before had access to it. For the first time in human history, a common global marketplace of ideas and resources is not only possible but active and growing.

Getting Connected

How does one get connected to this expanding marketplace of resources? In the humanities, most scholars still teach at colleges or universities, most of which have access to the Internet, so individual scholars can get connected through their institutions. Individuals in urban areas can subscribe to private servers providing access at rates that are very reasonable, at least in Oregon. Persons in rural areas can subscribe if they are willing to pay long distance costs to make the telephone/modem connections to the urban server. "Access" may be the central issue that determines what the Information Age will look like in the next century. The new fiber optics technology required to transmit the future's increasing amount of data is just now going into place, with urban centers getting first priority. Political and business decisions may not always provide what is best for the educational and scholarly communities, and even in areas where the technology is already in place, local politics and local administrative concerns, such as budget priorities, may delay access.

There is another obstacle to greater connection to the Internet by K-12 schools: many teachers are not making the world's resources available to their students because they themselves are not comfortable with the mechanics of gaining access. Greater computer education for teachers is necessary before educational Home Pages like Vince Ruggiano's become the rule rather than the exception.

"Internet in Beaverton Schools is in its infancy," says Ruggiano. "But there is no shortage of ideas for Internet use. I want my kids to use Internet databases for research, download graphics for use in multimedia presentations, link up with subject-area experts, do interactive science-math-literature projects with students all over the Net, share projects with student peers and have access to a multi-cultural environment."

Is Knowledge the New Tyranny?

If the challenge of providing widespread and inexpensive access to the resources on the Internet is not met, knowledge may well become the new tyranny, creating a society separated by information "haves" and "have-nots." The flip side of a global electronic democracy is an aristocracy of learning where only the fortunate (those who "qualify" by location or wealth or standing) are given access to the new electronic networks of information - and by access are given power. As we head into the Information Age of the twenty-first century, there are as many doomsday as utopian scenarios of the future. In his thought-provoking book, Information Warfare (Thunder's Mouth Press, 1994), Winn Schwartau writes:

> Today our challenge is ... to set up housekeeping in Cyberspace before the guests arrive. We have to define our future role in the global village, not let those stronger and better prepared dictate our limitations or cause us to be victimized.

The "case studies" I have told here are examples of how those with access can use the Internet to educational advantage. The challenge of the future is to make these stories common, no matter where a person lives.

Charles Deemer is active on the Internet as the editor-in-chief of "Stories from Downtown Anywhere," a collaborative hypertext novel, and as the author and editor of "The Screenwriters' & Playwrights' Home Page" on the World Wide Web. His new books are The Deadly Doowop, an electronic mystery (Jacobs Publishing), and Ten Sonnets, a chapbook (Irvington Press).

The Online Classroom: Computer Networks offer New Resources

Philip Cohen

I am a girl and I'm 11 years old. I want to have a pen pal. I like soccer, music, swimming, animals, reading books, boys and to be with friends. I can't speak English very well, I will try anyway. My idols are Bryan Adams, Mariah Carey, Ace of Bace.

The message is not remarkable, but for many people the context is. Joanna sent her message electronically - via e-mail - from her school in Finland to students and teachers around the world, through a vast computer network called the Internet. She and her pen pals are all participating in the "virtual community" of telecommunicators, which is doubling its population every year.

Educators looking to make classrooms more student centered, collaborative, and interactive are increasingly turning to telecommunications networks. Ranging in scale from local bulletin board systems (BBSs) to the Internet - the network-of-networks that connects more than 20 million users - these webs of connected computers allow thousands of teachers and students to reach each other directly - and gain access to quantities of information previously unimaginable.

Some planners believe that network technology will free schools from traditional budget constraints and increase the quality of information available to all classrooms. According to the National Education Goals Panel, the medium promotes "a dramatically decentralized and essentially democratic learning environment." For many people, networks are important tools for school reform.

"During the next decade, these emerging capabilities will leverage dramatic improvements in education," says Chris Dede, professor of information technology and education at George Mason University.

Beverly Hunter, educational strategist for Bolt Beranek and Newman in Cambridge, Mass., in the forthcoming book, *Public Access to the Internet* (edited by James Keller), writes that the "central value" of networking is its capacity "to support or enable authentic learning experiences and cross-institutional collaborations needed for reform of education."

Possibilities

Teachers can use networks to communicate with each other, gather information, and reduce professional isolation. Students using networks not only learn new inquiry and analytical skills in a stimulating environment, but, many people believe, they also gain an increased awareness of their role as world citizens.

In rural districts, computer links

can bring students into contact with other students and provide resources they might otherwise never obtain.

- The Shadows project, for example, organizes children internationally to measure the noontime shadows of a meter stick standing upright in their schoolyards. Then they share data over the Internet and use it to study the Earth in its relation to the Sun - while encouraging a common sense of purpose across cultural and geographic borders.

- In Clair Linker's 1st grade class at North Ridge Elementary School in Raleigh, N.C., students brought network technology to bear on what would have been a routine math project, counting M&M candies. They entered data onto a spreadsheet, then exchanged their information via e-mail with a class in a nearby rural town. "The whole idea of the project was just to introduce them to a new way to communicate," Linker says. Her lesson included conceptual skills - comparing the U.S. mail to e-mail - and practical skills.

- K12Net, a network of local bulletin board systems that exchange information with each other and connect to the Internet, offers specific discussion areas, or conferences, and interactive "chat" sessions for students and teachers. Teachers use K12Net to exchange classroom-to-classroom project ideas and proposals. The contact between students promotes "a commonality that transcends politics and traditional stereotypes to create a truly global village," says Janet Murray, librarian at Wilson High School in Portland, Ore., and a founding member of K12Net's Council of Coordinators.

- The Mendocino Unified School District in California in many ways exemplifies the ideal toward which telecommunications advocates are striving. With help from NASA's High Performance Computing and Communication K-12 Partner School Program and from private industry, Mendocino has established a direct Internet node - which allows much faster and more efficient access for more users than a simple phone line. In exchange for financial and technical support, the district agreed to design curriculums that NASA in turn distributes via the Internet. After initial technical training, Mendocino teachers began developing appropriate curriculums. Twenty staff members spent three days visiting scientists at NASA. Grant funding allowed the district to offer small stipends for the training, and with modems at home some teachers could receive instruction through a dial-up program. Mendocino teachers and students use their Internet connections for science research projects, while language arts teachers pursue collaborative writing and literature projects. To more fully integrate the new tools, the middle school set up three-hour project periods one day per week, allowing students adequate time to delve into the network.

Curriculum Challenges

Leisa Winrich, who teaches students with learning disabilities at North Middle School in Menomonee Falls, Wisc., con-

Teachers can use networks to communicate with each other, gather information, and reduce professional isolation. Students using networks learn new inquiry and analytical skills in a stimulating environment.

nected her mathematics students to the KidLink network to share local weather data with distant classes. The Menomonee students compile the international data and send it back out over the network. "We discovered that math does help us communicate," says Winrich. "We can grow to better understand our global neighbors and their environments by exchanging and studying numbers."

Integrating network technologies meaningfully into the curriculum is a pressing concern, and experts issue a cautionary note. The promise of new technology will only be realized "if practitioners master how sophisticated technologies empower more effective models of teaching, learning, and leadership," says Dede. Hunter concurs, adding, "There is a danger that the networks could be used to transmit and amplify traditional and outmoded elements of schooling."

Unless network technology promotes interdisciplinary, interactive projects, educators may not use networks as a "catalyst for changing schools," says Jo Blackwood, communications teacher at Capital High School in Charleston, W. Va. When she helped set up network training for district teachers, Blackwood made sure to include curriculum development. "You can't just do it in isolation," she says. And funding for new technologies often is directed too much toward the technical side. The result can be using computers as "electronic books," she has found. "That's not taking advantage of the assets the technology can provide."

In Devils Lake (North Dakota) Public Schools, access to a network has not automatically led to interdisciplinary approaches. Most teachers using the network "do so within the confines of their discipline," says Technology Coordinator Sam Johnson.

Access and Barriers

Vice President Al Gore has challenged communications industry leaders to connect every classroom to the National Information Infrastructure, the so-called information superhighway, by 2000. But U.S. Commerce Secretary Ron Brown earlier this year reported that only a "small fraction" of classrooms have access to computer networks - or even telephones.

States can apply for federal aid under Goals 2000 to develop telecommunications networks, and the latest federal budget includes $700 million for the National Information Infrastructure over the next five years. More than half the states now provide an educational network. Though access is far from universal, examples of rapid growth abound.

- North Dakota State University developed NoDak, a network for educators and students, with outside funding. At the end of 1992, the system had some 1,500 users. By August 1994 it had grown to include almost 10,000 users at all but five of the state's 265 school districts.
- About one-quarter of Texas public school teachers regularly log in to the Texas Education Network, TENET.
- More than 40,000 people now use PBS Online's Learning Link by dialing up to BBSs at local public television stations.
- NASA's Spacelink system has grown from a dial-up BBS in 1988, receiving 500 calls a month, to an Internet host "visited" by more than 1,000 people per day, who use it to gather everything from lesson plans to information on the current Space Shuttle flight.
- AskERIC, a project of the ERIC Clearinghouse on Information & Technology at Syracuse University, receives more than 300 electronic mail requests for information per week. The service provides sample ERIC database searches, lesson plans, or references to more information.

Although some 80 percent of computers now in schools are too old to be useful for networking, according to the Commerce Department, Murray believes that "much could be accomplished with existing equipment if access and training were available." Networks such as K12Net offer "training wheels," requiring only a computer, modem, a single phone line, and basic training. Some programs, including the Global Laboratory from TERC in Cambridge, Mass., offer quick entry into existing projects and connection to other classrooms with similar interests and needs.

Still, schools are significantly behind private industry and even American homes, almost one in six of which now has at least one computer connected to a modem. To take full advantage of the telecommunications networks, experts say, requires school district planning, teacher training and support, comprehensive curriculum integration, effective assessment, and significant infrastructure investment.

Dede argues, however, that "the most important barriers are not technical or economic - although these are significant - but psychological, organizational, political, and cultural. "When teachers and learners and parents want sophisticated, interactive technologies and know how to integrate these into new models of learning," he believes, "then the technical and economic barriers can be overcome with relatively little difficulty."

Mendocino Technology Coordinator Mark Morton agrees. "I think access will not be an economic issue in the future," he says. "Just as televisions and phones are not so much of an issue now." With increasing access, technical aspects will become less important and "the content and structure of the information" will determine the medium's value to education. "Will we know how to use these incredible tools well?" Morton asks. "We didn't do too well with TV, but I have a lot more faith in this technology" because of its interactive nature. "Millions of people are involved in creating this communication space, not just a few."

A closer look: Network Possibilities

Chris Dede, professor of information technology and education at George Mason University, puts the use of telecommunications into three categories. To take advantage of network technologies, he believes, curriculum developers should seek a balanced integration of each:

- Knowledge utilities. Information resources and tools teachers and students use to gather information: libraries, databases - and other people, as with widely distributed inquiries.
- Virtual communities. "Psychosocial" or "emotional" areas: people supporting each other and sharing common experiences; increasingly, this takes place through long-distance collaborative learning projects between students or educators, newsgroups, or online conferences.
- Synthetic environments. Less frequently employed, this involves "putting people into a shared virtual world," such as an online text-based museum or a mutually created simulation, and allowing students or teachers to explore and create together.

FYI: Start-up Resources

Many network service providers exist - national, regional and local. Directories are available in most bookstores. Educational resources are also numerous. Here are a few samples:

- K12Net. A network of bulletin board systems for teachers, students and parents: Contact Janet Murray at (503) 280-5280, ex. 450.
- I*EARN. The International Education Resource Network, connecting students and teachers internationally with electronic mail, conferences, and travel exchanges: (914) 962-5864.
- PBS Online's Learning Link. A network of bulletin board systems based at local public TV stations: (703) 739-8464.
- Global SchoolNet. Develops collaborative electronic mail projects: (619) 475-4852.
- International Society for Technology and Education. Promotes use of technology in schools: (503) 346-4414.
- TERC. Devoted to math and science, network programs include Global Laboratory and LabNet: (617) 547-0430.
- Classroom Connect. A monthly educator's guide to Internet and commercial online services: (800) 638- 1639.

ASCD will have a new public-access gopher site available on the Internet January 1. The address is gopher.ascd.org. Questions or comments are welcome; write: update@ascd.org.

Philip Cohen is staff writer of ASCD *Update*, the official newsletter of the Association for Supervision and Curriculum Development.

Grazing the Net: Raising a Generation of Free Range Students

Jamie McKenzie

The student sits at a classroom computer grazing Internet - a global network linking the student with vast databases, innumerable bulletin boards and millions of users. The potential is amazing. The information harvest could be impressive. Schools that can afford it are rushing to install WANs (wide area networks), LANs (local area networks) and Internet nodes so that all classrooms might sit down to sample the electronic feast. Access becomes priority - for some it becomes obsession. But shouldn't we be asking some important questions about this miracle? If highways are a mixed blessing - carrying some to grandmother's house for dinner but crashing others who have celebrated to the extreme - then what are the risks associated with the Net and how might we minimize them? How might we take advantage of the Net to raise a generation of free range students?

Students as Infotectives

The rich information resources to be found in cyberspace (the Internet) are both a blessing and a curse. Unless students have a toolkit of thinking and problem-solving skills which match the feasts of information so readily available, they may emerge from their meals bloated with techno-garbage, information junk food or info-fat. We must teach students to graze and digest the offerings thoughtfully in order to achieve insight.

We must guide our students to become infotectives. What is an infotective? . . . a student thinker capable of asking great questions about data (with analysis) in order to convert the data into information (data organized so as to reveal patterns and relationships) and eventually into insight (information which may suggest action or strategy of some kind). An infotective solves information puzzles and riddles using all kinds of clues and new technologies. The problem-solving which often follows the detective work then requires synthesis (invention) and evaluation (careful choices from lists of options). An infotective is a skilled thinker, researcher and inventor.

Infotective is a term designed for education in an Age of Information. In the smokestack school, teachers imparted meanings for students to digest, memorize and regurgitate. In Information Age schools, students make the meaning. They puzzle their way through piles of fragments - sorting, sifting, weighing and arranging them until a picture emerges. (Power Learning, McKenzie, Corwin Press, 1993)

Unless we are connecting with Internet for edutainment, student questioning must be intense before, during and after visiting cyberspace. We must teach students to start with what Sizer calls "essential questions" - the kinds of probing inquiries which might extend over a month or a lifetime - questions worth asking, which touch upon basic human issues - investigations which might make a difference in the quality of life - studies which might cast light in dark corners, illuminating basic truths. And then we must teach them how to conduct a thorough research study. Questioning persists throughout all stages of such a study.

Sample Research Question (Secondary)

"Imagine that you and your partners are consultants hired by the states of Washington and Oregon to recommend new policies to stem the decline of the fish harvests in the region during the past decade. Use Internet to identify all useful practices already tested around the globe and then determine the applicability of these practices to the particular conditions and needs of the Northwest. Create a multimedia report for the two governors sharing specific action recommendations as well as the evidence sustaining your proposals."

Unfortunately, schools have traditionally neglected the development of student questioning. According to Hyman (1980), for every 38 teacher questions in a typical classroom there is but one student question. Schoolhouse research, sadly, has too often fallen into the "go find out about" category. Topical research (Go find out about Dolly Madison) requires little more than information gathering. We must move beyond this traditional search for answers to simple questions.

Instead of asking elementary students to find out all they can about a particular state or nation, for example, we should be asking them to compare and contrast several states or cities for a purpose - sifting, sorting and weighing the information to gain insight, to make a decision or to solve a problem.

Sample Research Question (Elementary)

"Imagine that your parents have been given job offers in each of the three following cities: New Orleans, Seattle and Chicago. Knowing of your access to Internet, they have asked you to help them decide which city will be the best for the family to select. Before gathering your information, discuss and identify with them the criteria for selecting a home city. Create a LinkWay or HyperCard stack showing the strengths and weaknesses of each city on the criteria your family considers important."

Conducting topical research on the Internet is a bit like pedaling a tricycle on the Interstate. To mix metaphors, classic school research projects (finding out about a particular state) are too much like shooting at sitting ducks.

Creating Constructivist Classrooms

Marty and Jacqueline Brooks' 1993 ASCD publication *In Search of Understanding: the Case for Constructivist Classrooms* makes a great primer for those who would like to develop classrooms which would fully entertain the potential of grazing the Net. The title of one chapter, "Coming to Know One's World," seems such an apt way of thinking about exploring the Net. The guiding principles of constructivism match the themes of this article:

- Posing problems of emerging relevance to students.
- Structuring learning around primary concepts: the quest for essence.
- Seeking and valuing students' points of view.
- Adapting curriculum to address students' suppositions.
- Assessing student learning in the context of teaching.

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A list of descriptors portrays constructivist teachers as ideal partners to student Internet explorers:

1 Constructivist teachers encourage and accept student autonomy and initiative.
2 Constructivist teachers use raw data and primary sources, along with manipulative, interactive, and physical materials.
3 When framing tasks, constructivist teachers use cognitive terminology such as "classify," "analyze," "predict," and "create."
4 Constructivist teachers allow student responses to drive lessons, shift instructional strategies, and alter content.
5 Constructivist teachers inquire about students' understanding of concepts before sharing their own understanding of those concepts.
6 Constructivist teachers encourage students to engage in dialogue, both with the teacher and with one another.
7 Constructivist teachers encourage student inquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other.
8 Constructivist teachers seek elaboration of students' initial responses.
9 Constructivist teachers engage students in experiences that

might engender contradictions to their initial hypotheses and then encourage discussion.
10 Constructivist teachers allow wait time after posing questions.
11 Constructivist teachers provide time for students to construct relationships and create metaphors.
12 Constructivist teachers nurture students' natural curiosity through frequent use of the learning cycle model.

pp. 103-117

This excellent book should sit right alongside your copy of the Dummy's Guide to the Internet. It makes little sense to set students free to graze cyberspace if classrooms do not nurture the kinds of thinking and learning described by the Brooks.

Eisenberg's Big Six Skills - Information Problem-Solving

Unfortunately, the K-12 literature on a district-wide approaches to research by students is thin. It has long been dominated by discipline-specific models (from social studies, science, etc.) which do not always dovetail with each other, and these usually fail to address the kind of research which will be possible with the Net. In developing district plans to exploit the full potential of cyberspace, we must come to agreement on core research skills.

Eisenberg's Big Six is one promising model for school research, one frequently cited on the Library-Media bulletin board on Internet.

Eisenberg's Big Six

1. Task Definition
   1.1 Define the problem
   1.2 Identify the information requirements of the problem
2. Information Seeking Strategies
   2.1 Determine the range of possible sources
   2.2 Evaluate the different possible sources to determine priorities
3. Location and Access
   3.1 Locate sources (intellectually and physically)
   3.2 Find information within sources
4. Use of Information
   4.1 Engage (e.g., read, hear, view) the information in a source
   4.2 Extract information from a source
5. Synthesis
   5.1 Organize information from multiple sources
   5.2 Present information
6. Evaluation
   6.1 Judge the product (effectiveness)
   6.2 Judge the information problem-solving process (efficiency)

Michael B. Eisenberg and Robert Berkowitz Information Problem-Solving: The Big Six Skills Approach to Library and Information Skills Instruction (1990, Abblex Publishing, Norwood, NJ) Page 35

Unfortunately, this model, while intended to promote higher level thinking, can too easily be used to perpetuate the information-gathering and topical research patterns warned against in the previous section. A careful reading of the full text of Eisenberg's model raises the following issues:

1 Information is not the same as knowledge or insight. We are overwhelmed suddenly with information. What we need is insight. Insight answers the "So what?" question. Insight helps to guide decision-making. Eisenberg's model tells us too little about the path from information to insight.
2 Information problem-solving is not the same as problem-solving. Classic problem-solving models call for repeated information gathering all along throughout the process, but the gathering of information is usually in the service of synthesis (invention) and evaluation (decision). Eisenberg's section on Synthesis (Step Five) devotes too little attention to the thought process required by a fifth grader or a team of eleventh graders who have collected 455 pages of text and data tables on the Internet. How do they take those fragments, weigh them, assess their reliability and validity and then apply them to the questions at hand to achieve some new understandings? This is one of the biggest challenges facing teachers guiding students into (and out of) cyberspace. "What do I do with all the stuff once I have it? How do I screen out the garbage, know what is propaganda and what is distorted? How do I guard against what Toffler calls 'info-tactics?'" And Eisenberg's section on evaluation relates primarily to considering whether the research has been conducted in a thorough and effective manner. He does not develop either synthesis or evaluation in terms of general problem-solving and decision-making models such as the one employed by Human Synergistics.
3 Students may not understand the problem well enough to define it. Eisenberg properly warns that too little attention is usually devoted to the problem and task identification stage, but premature attention to either task

may skew the research toward inappropriate or biased data sources. In the case of the fisheries simulation outlined above, students might be wise to start with several hours of grazing Internet to develop entry level awareness of key issues and aspects of the problem being studied.

4 Students may not know what they don't know. It is difficult for students to plan investigations into complex and essential questions because they are often exploring virgin territory or regions which are quite foreign to their experience. It is one thing to collect the opinions of literary critics about *Lord of the Flies* and summarize their views - quite another to read them, digest them, weigh the work itself and come to a fresh synthesis which includes the researcher's own views. It is easier to follow Eisenberg's steps when collecting information to match clear targets than when muddling through truly challenging questions.

5 Information seeking to solve real problems is recursive. Eisenberg makes it abundantly clear in his book that one may keep circling and cycling back through the six steps of his model, but that section of the book can all too easily drop away in school translations which are printed up on charts to guide students. The importance of refreshing questions throughout the investigation can be forgotten in the rush toward answers.

6 Internet supports information cultivation as well as harvest. The Big Six steps relate most appropriately to existing information, but Internet allows students and classes of students to form information collaboratives designing and implementing research on issues like acid rain. The Big Six are a wonderful platform for a district discussion of research skills, but they require revision and adaptation to match the potential of the Net.

Preparing Students for Cyberspace - Internet Competencies

Internet poses a difficult challenge . . .

How will the voyager know when they have found truth? Answers will be a dime a dozen. Insight, on the other hand, may be rare. Without some grounding in epistemology (a theory of the nature of knowledge), we may raise a generation rich in data, facts and information but lacking in wisdom.

Success in cyberspace will require many of the following skills:

Framing essential questions

Already outlined earlier in this article, various publications of the Coalition of Essential Schools do an excellent job of describing what this skill entails and includes. Both Ted Sizer and Grant Wiggins have published good work on this topic.

Identifying subsidiary questions

Great questions spawn countless related questions which should then begin to suggest an Internet path for the researching team. Question-webbing is a powerful mapping tool to guide Internet voyages. Each voyage will probably suggest new questions as the unknowns become better known.

Planning a cyberspace voyage

The charm and power of Internet is often found in its surprises. A good rule of thumb is to expect that 80 per cent of the wisdom collected will result from information sources unknown at the commencement of the voyage. The best plan, then, may be a flexible one concentrating on bold strokes like "I think I'll start with Veronica and plug in some keywords to see what comes up."

Learning on the run

Like any good detective, the infotective keeps looking for clues and new sources even as the information begins scrolling past. Because software allows for hundreds of pages to be downloaded at amazing speed for reading later, the voyager can hop, skip and jump through the sources trying to pick up new possibilities. It is a good idea to remember that one is not trying to find answers yet. It is a search for possibilities. Cast the net far out.

Changing course

The journey will lead up blind canyons and sometimes prove frustrating. Effective exploration may require the energy and flexibility of a pin ball jumping and bouncing around at incredible speed.

Exploiting serendipity

Even though our culture often conspires to protect us from surprise, much of the power of Internet is to help us escape the boxes within which we live. We have carefully screened out information most of our lives. We are too often the prisoners of our cultures, our educational experiences and our biases. Internet can set us free.

Asking for help

Ranging through dozens of different information sources the searcher often encounters conflicting and often confusing command structures. To prevent gridlock and wasted time, it makes sense to browse the help menu of these sources early in the game. "You mean I could have saved that file? If only I had known!"

Asking for directions

According to popular stereotypes, men never ask for directions when they are lost. It makes sense to have several Internet guides at the ready and a friend to call when lost. Commentators claim that Internet is often "arcane." That simply means it may be easy to get lost.

Screening and compacting garbage

TQM has not reached the Net. There is little quality control. Bulletin boards overflow with loquacious pedantry and bias masquerading as informed opinion. In smokestack schools students were sometimes urged to reach out toward big page numbers. A good report was a long report. Now it is so easy to download and then cut and paste hundreds of pages of text into a report that it becomes important to cull the essential, meaningful and reliable data. The garbage is set aside, compacted and discarded. The student establishes criteria for reliability and applies them to separate wheat from chaff. Key action verbs: choose, pick, select, separate, sift, and single out.

Sorting data

In the process of collecting data, which may arrive in graphic form, as text or as numerical data, students must begin organizing and reorganizing the data in order to find patterns and relationships. This process is the foundation for analysis and synthesis. Key action verbs: align, arrange, array, assort, catalog, categorize, class, classify, cluster, compile, file, grade, group, layout, line up, list, order, organize, outline, pigeonhole, place, position, prioritize, program, rank, stack, tabulate. Associated tasks: bracket, collate, compare, contrast, correlate, equate, liken, match, relate.

Analyzing data

As the data is collected, screened and sorted, the student keeps questioning in order to convert the data into insight. The student approaches understanding - "the big picture" - by undertaking many of the following actions: clarify, interpret, construe, deduce, derive, educe, gather, glean, infer, interpret, surmise, examine, probe, and unravel.

Navigating in the dark

It is no accident that many boat chartering companies refuse to allow their customers to navigate in the dark. Darkness shifts perception and creates confusing illusions. A vast percentage of the visual cues upon which the casual sailor relies to guide the vessel are eliminated and replaced by a much more challenging system of lights. At times, the Net provides rich cues to guide one through the shallows and shoals. At other times, it seems like sailing in the dark. Ironically, most essential questions bring us into contact with darkness and the unknown. We often seek illumination in aspects of our lives which are the most frustrating. The simple answers, the conventional wisdom and the easily accessible recipes are often poor substitutes for the insights that emerge from night sailing. The best navigators learn to sail by the stars.

Navigating in the mud

What sailor has never mis-timed the ebbing tide to find the boat wedged in mud? Who has never misread a chart and felt the sudden dragging warning along the keel of soft, sucking mud? The Internet offers its own information mudflats, vast expanses of soft data and opinion which can bog us down and slow our search for truth. Students must learn to skirt the shoals unless they are seeking shellfish buried within.

Scanning from the crow's nest

Maintaining perspective is paramount. While conducting research we can be trapped in the day-to-day survival activities going on at the deck level. We are too close to the action to see the patterns in it. "Climbing the mast" means stepping outside and above the activities to see them with some distance and perspective. The crow's nest allows one to look beyond the ship to ask questions about the challenges and goals which lie ahead. It means keeping the big picture and the essential questions in mind.

Building and testing models

Model building is a form of synthesis which allows one to combine the key elements of a process or a system in a simplified version which permits manipulation of variables in order to explore relationships. Both the NCTM standards and Project 2061 call for students to learn both model building and systems thinking because they offer such explanatory power. The Systems Thinking and Curriculum Innovation Network Project (STACIN) developed by ETS, has been exploring the use of a software program called STELLA, a simulation-modeling package, for eight years with high schools and middle schools. An authentic outcome of an Internet research project might be the development of a model to show the interplay of key elements in the ecosystem of a timber wolf family.

Creating fresh answers and insight (synthesis)

Smokestack schools often relied too heavily on the collection and re-hashing of old insights. Students were too rarely challenged to develop their own fresh insights. Sorting and sifting through the data they have collected on the Net, they arrange the jigsaw pieces and fragments without ever being shown the picture. They are "on their own." Picture a student or a team of students actually manipulating their fragments to see what insights might leap forth. Software programs like the electronic thesaurus and various outlining and idea processing programs may help with the visualizing and thought play. To close the gap between information and insight, students are conjuring up new possibilities such as an array of strategies uniquely suited to protect and enhance the salmon harvest in their particular part of the Puget Sound.

There are at least three associated levels of thinking which must all occur at the same time in a dynamic, triple decker process which is a great deal like writing poetry or songs. All three levels operate concurrently and recursively (like the cat chasing its tail).

1. Envisioning

The top level involves conjuring and envisioning types of thought. The students conceive, conjecture, fancy, imagine, project and visualize. Envisioning is the top level because it lifts the product and outcome of the thinking beyond the past practice and old thinking. The thinker leaps out of the box of everyday, ho-hum thinking. Of course, grazing the Internet lends itself especially well to the encouragement of such flights of fancy. The Net provides the excursions, journeys, safaris, sallies, treks and spins trainers often employ to stimulate creative problem-solving in groups (Synectics). Envisioning is the source of originality. Identifying possibilities and exploring the unthinkable is basic to this level.

2. Inventing

The middle level requires translation of possibilities into actualities. The imaginative play of the top level must be grounded in reality. What might actually work? What is a sensible version of that possibility? This is the level at which innovation is born. The student concocts new solutions to problems or coins new ideas and general principles. The research team may hatch a whole new action plan, fabricating and formulating initiatives to clean up local streams. Perhaps the thinking may advance to the development and testing of prototypes before engineering a final product.

3. SCAMPERING and Rearranging

The foundation for the top two levels is the rearranging mentioned earlier in this article in the sections on sorting and analyzing data. One model for such synthesis is SCAMPER (Osborne), with each letter standing for a strategy. S=substitute. C=combine. A=adapt. M=modify, magnify, minify. P=Put to other uses. E=eliminate. R=reverse. For this level to produce powerful results, the other two levels must be operating concurrently, as they supply the pressure and cognitive dissonance which inspires creation. The student arranges, blends, combines, integrates, tests, and adjusts the thought fragments until new pictures emerge.

Suggesting and testing hypotheses

"What if . . . " thinking helps to propel and inspire mindful, purposeful research through the Net. The student learns to brainstorm multiple explanations and possibilities and then sets out to see which have the most explanatory value.

Opening one's mind

Fundamental to the creation of new knowledge and insight is the process of suspending bias, challenging assumptions and noting premises. The researcher understands that the final product of the search will be made up of three related elements: assumptions, evidence and logic. All three must be opened to careful review and examination.

(The next portion on open minds is adapted from Administrators at Risk: Tools and Technologies for Securing Your Future, McKenzie, National Educational Service, Bloomington, IN, 1993.)

What is an open mind?

A mind which welcomes new ideas.
A mind which invites new ideas in for a visit.
A mind which introduces new ideas to the company which has already arrived.
A mind which is most comfortable in mixed company.
A mind which prizes silence and reflection.
A mind which recognizes that later is often better than sooner.

An open mind is somewhat like silly putty. Do you remember that wonderful ball of clay-like substance that you could bounce, roll and apply to comics as a child?

An open mind is playful and willing to be silly because the best ideas often hide deep within our minds away from our watchful, judgmental selves. Although our personalities contain the conflicting voices of both a clown and a critic, the critic usually prevails in our culture. The critic's voice keeps warning us not to appear foolish in front of our peers, not to offer up any outrageous ideas, and yet that is precisely how we end up with the most inventive and imaginative solutions to problems. We need to learn how to lock up the critic at times so the clown can play without restraint. We must prevent our internal critic from blocking our own thinking or attacking the ideas of others.

An open mind can bounce around in what might often seem like a haphazard fashion. When building something new, we must be willing to entertain unusual combinations and connections. The human mind, at its best, is especially powerful in jumping intuitively to discover unusual relationships and possibilities.

An open mind quickly picks up the good ideas of other people, much like silly putty copying the image from a page of colored comics. The open mind is always hungry, looking for some new thoughts to add to its collection. The open mind knows that its own thinking is almost always incomplete. An open mind takes pride in learning from others. It would rather listen than speak. It loves to ask questions like, "How did you come up with that idea? Can you tell me more about your thinking? How did you know that? What are your premises? What evidence did you find?"

The open mind has "in-sight" - evaluating the quality of its own thinking to see gaps which might be filled. The open mind trains the clown and the critic to cooperate so that judgment and critique alternate with playful idea generation. Ideas have at least three major aspects which can usually be modified and improved:

1 Ideas are based upon premises of one kind or another. Many people come to their ideas (judgments or conclusions) without ever explicitly examining the premises which lie underneath those conclusions. Premises are basic beliefs which act for an idea as the foundation of a building or the roots of a tree. Collections of premises are often called assumptions or mind-sets (Drucker, 1992) or paradigms (Barker, 1992) or mental models (Senge, 1991). Sometimes our thinking comes to us already packaged without our even knowing which premises and assumptions lie below the surface, but an open mind knows that all such premises must be re-examined with some frequency to see if they are serving us well and truly match our basic belief systems.

2 Ideas are based upon evidence. Many of our ideas emerge from experience. We collect data, look for patterns and seek laws to help us predict the future. Unfortunately, we all too often collect evidence selectively. Once people begin to hold an idea, research has shown that they begin to screen out data which might create dissonance, evidence which might "call into question" the value of the idea. An open mind looks at the quality of its evidence with the same dispassionate attitude it applies to its premises and assumptions. Mindful of the three little pigs which built houses or straw, twigs and brick, the open mind seeks bricks and mortar which can withstand the huffing and puffing of the most aggressive wolf. The open mind asks, "What evidence do I need to gather? Do I know enough? Has anything changed since I last gathered evidence? Is there new data? Is my data complete?"

3 Ideas are based upon logic. Our conclusions and ideas should flow from logical connections between our premises and our evidence. The open mind keeps asking of its ideas, "Is this logical? Does this make sense? Does this follow from the evidence I gathered? Have I identified all the key factors?

Seeing what's missing

At times, the enormity of the data cascading into our computers creates the false impression that we have fully explored some topic. Experience shows that even when we have mountains of data, we may have missed really important articles or data because we encountered one of the following problems:

1 Flawed search strategies. We pick the wrong search term, one not included in the keyword lexicon of the particular database. Hitting few articles, we conclude that little has been written on that topic. Perhaps if we replace "instructional technology" with "educational technology" we will hit a rich vein of literature. We learn to doubt the efficacy of our search words and check the lexicons.

2 Biased databases. Even though we would like to believe otherwise, some groups and some aspects of history are systematically avoided or ignored by data sources. I recently searched an electronic encyclopedia in preparation for a third grade unit on Native Americans and found that the word "broken" never occurred in the same article with

the word "treaty." In reading some of the articles which held the word "treaty" I was struck by the carefully sanitized phrasing of how tribes were relocated. The trail of tears had been expunged from most tribal histories.

3 Overloaded databases. Conducting a Veronica search of Gopherspace with the search term "technology" I encountered thousands of articles. Scrolling through the first several hundred titles, I noted a huge number of articles about technology in the timber industry. Why did this particular group dominate the first part of the list? I hypothesized that because much research in this nation has been funded by government and industry, the files presently available in university libraries may be the result of such projects. A student team browsing such a list might think they had hit the "mother lode" of data on timber management, but they need to identify the source and know that balance can only be achieved by seeking what is missing. What data would emerge in a search of databases provided by environmental groups?

4 Wrong database. Even though gopher programs and knowbots are linking users to multiple data sources without requiring customized scanning, these programs do not offer access to all appropriate databases. They may give the false impression of comprehensive coverage while actually missing key sources.

Recognizing anomaly

Cyberspace provides a rich offering of anomalies (American Heritage Dictionary: deviation from the normal or common order or form or rule; abnormality). These anomalies can be a great source of inspiration and invention during times of rapid change. They are outstanding events. They stand as extra-ordinary. They are, by definition, out of the box. They may be glimpses of our futures. Students can be taught to seek, capture and examine such irregularities, remembering that penicillin was discovered because of a laboratory error that grew a mold by accident. The Internet may offer many powerful accidental discoveries.

Conclusion: Raising A Generation of Free Range Students

What is a "free range student?" It is simply a student fed on the wild grains and fragments available in the magical world made accessible by the Net. Just as some gourmets prefer free range chickens to their plump cousins raised on processed grains and feed heavily impregnated with hormones and chemicals, the theme of this article is the value of raising children to think, explore and make meaning of their worlds for themselves. No more second hand knowledge. No more sage on the stage. Students will learn to make sense out of nonsense and order out of chaos. They will ask essential questions and solve complex problems. They will join electronically with brothers and sisters around the globe to cast a spotlight on earth-threatening issues which deserve attention and action. The Net offers amazing freedom of access to information. But Info-Heaven can quickly become Info-Hell if we do not equip our students with the reasoning and exploration skills required to cope with Info-Glut and Info-Tactics. To a large extent, the value of cyberspace resides in the minds of the voyagers.

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The Well-Rounded Curriculum

Applying the Theory of Multiple Intelligences

Scott Willis

Sandy, an elementary student, is struggling with the concept of multiplication. Because she is talented in art, her teacher asks her to create visual representations of the times tables. Sandy dives into the task with relish, drawing configurations of objects to depict "two times two," "two times three," and so on. When she is finished, she understands multiplication, because the concept has been expressed through visual images.

In tapping Sandy's visual-spatial intelligence, her teacher is applying the theory of multiple intelligences, which Harvard psychologist Howard Gardner set forth 11 years ago in his book *Frames of Mind.* Gardner argued that our traditional conception of intelligence - as primarily linguistic and logical abilities - is too narrow, and that all human beings actually have seven distinct intelligences (see box).

Some educators who find Gardner's theory intuitively appealing are working to address all seven intelligences in their classrooms. Doing so helps students become more well-rounded, makes school more engaging and motivating, and enables more students to succeed, these educators say.

By cultivating a broad range of intelligences, teachers can uncover hidden strengths among students who don't shine at verbal or mathematical tasks. Similarly, students who are gifted in a paper-and-pencil environment may be weak in other areas, such as bodily-kinesthetic, spatial, or interpersonal skills. Teachers should nurture all students' strengths and challenge them in areas where they are less developed, says Thomas Armstrong, an education consultant and author of ASCD's *Multiple Intelligences in the Classroom.*

There is no recipe for applying the theory of multiple intelligences. Gardner himself considers his theory "a Rorschach blot", because educators can draw diametrically opposed conclusions from it. Some might choose to identify students' strengths and focus on nurturing them; others might identify weaknesses and work to shore them up; still others might give equal time to all seven intelligences. Although Gardener does not endorse any particular approach, he urges educators to take the differences among their students "very seriously." Get a lot of detailed, personal knowledge about how children's minds work - then use it to guide instruction, he advises. "Don't treat everybody the same".

A self-described "purist", Bruce Campbell, a teacher and staff developer in the Marysville (Wash.) schools, weaves all seven intelligences into everything he teaches in his non-graded elementary classroom. In teaching about photosynthesis, for example, Campbell might have his students read about the concept (linguistic), use diagrams (spatial), analyze the sequence of the process (logical-mathematical), dramatize the process or manipulate fact cards (bodily-kinesthetic), create a song about it (musical), work in groups (interpersonal), and do a reflective activity, such as comparing photosynthesis to a change in their own lives (intrapersonal).

To make this approach feasible, Campbell has created seven centers in his classroom, each focused on one intelligence. Students rotate through the centers for half of each day. Campbell emphasizes that he organizes the curriculum around themes. Teaching the traditional curriculum in all seven ways "would take 100 years," he says.

Dee Patrick, a teacher at Russell Elementary School in Lexington, Ky., also uses centers to help her students develop all seven intelligences. Five or six children work at each center for about 35-40 minutes, then rotate to the next. The centers are named after famous figures who exemplify the intelligences, including Martin Luther King Jr. (interpersonal) and Leonardo da Vinci (spatial).

Like Campbell, Patrick uses a thematic approach. In learning about outer space, for example, her students might design a constellation pattern (spatial), simulate walking on the moon (bodily-kinesthetic), and reflect on the Challenger disaster (intrapersonal). Students love working at the centers, Patrick says, and many strengths are revealed when they do.

SEVEN WAYS TO BE SMART

According to Howard Gardner's theory of multiple intelligences, all people possess seven distinct sets of capabilities. Gardner emphasizes that these intelligences work in concert, not in isolation. The seven intelligences are:

Spatial: The ability to perceive the visual-spatial world accurately and to perform transformations upon one's perceptions. This intelligence is highly developed in hunters, scouts, guides, interior designers, architects, artists and inventors.

Bodily-Kinesthetic: Expertise in using one's whole body to express ideas and feelings and facility in using one's hands to produce or transform things. Highly developed in actors, mimes, athletes, dancers, craftspersons, sculptors, mechanics, and surgeons.

Musical: The capacity to perceive, discriminate, transform, and express musical forms. Highly developed in musical performers, aficionados, and critics.

Linguistic: The to use words effectively, either orally or in writing. Highly developed in story-tellers, orators, politicians, poets, playwrights, editors, and journalists.

Logical-Mathematical: The capacity to use numbers effectively and to reason well. Highly developed in mathematicians, tax accountants, statisticians, scientists, computer programmers, and logicians.

Interpersonal: The ability to perceive and make distinctions in the moods, intentions, motivations, and feelings of other people. This intelligence can include sensitivity to facial expressions, voice, gestures, as well as the ability to respond effectively to such cues - to influence other people, for example.

Intrapersonal: Self-knowledge and the ability to act adaptively on the basis of that knowledge. This intelligence includes having an accurate picture of one's strengths and limitations, awareness of one's moods and motivations, and the capacity for self-discipline.

Adapted from the ASCD book "Multiple Intelligences in the Classroom" by Thomas Armstrong.

Addressing multiple intelligences "provides more students with opportunities for success," Campbell says. Among his students, he sees "different kinds of leadership emerging spontaneously" as children identify their own strengths and those of others. Some students are learning much better, he believes - those whose strengths do not lie in the linguistic or logical areas. And students are more accepting of one another.

One boy who had poor basic skills, low self-esteem, and no friends was transformed after other students realized he had "a remarkable propensity" for music, Campbell relates. As the boy began to use his newfound musical ability, his popularity and self-esteem rose. With a new, positive attitude toward school, he made strides in other areas, including reading and writing.

Recognizing multiple intelligences gives every student "the feeling of success," says Rhonda Flanery, another Russell Elementary teacher who uses intelligence centers. Because her class is not tracked into "the dummies, the okays, and the smarties," her students are less competitive and more willing to cooperate and share, she adds.

Teachers should not feel they have to work all seven intelligences into every lesson; such an approach is too rigid, says Linda Campbell of Antioch University, primary author of Teaching and Learning Through Multiple Intelligences. Incorporating even four intelligences into a lesson can be a "stretch," she believes. "You need some depth; otherwise teaching becomes cute and fluffy".

Teachers should not assume that all seven intelligences can be used to teach everything, Gardner cautions. In considering potential learning activities, teachers must ask first, "Is it sensible?" and second, "Does it work?"

Using Projects

While some teachers use centers, others apply Gardner's theory through interdisciplinary projects that call on students to use several intelligences.

At Skyview Junior High School in Bothell, Wash., 7th grade students study an integrated unit called "Genetics: Who Am I?" Science and math are the primary focus, teacher Jeff DeGallier explains, but the three-week unit also incorporates art, music, and other activities "to hit all the intelligences at least once."

Besides reading about genetics, students observe a simulation of pulling apart strands of DNA, write essays and poems on "nature vs. nurture", and create murals to express their identities. In math, students study probability to explore variation among traits - examining questions such as "What is the chance of having blue eyes?"

Teachers at Lincoln High School in Stockton, Calif., use a project-based approach that integrates science, social science, and language arts, says Pam Martin, a science teacher at the school. Teachers insist that students develop areas of weaknesses as well as capitalize on their strengths. "We emphasize students' looking at themselves holistically," Martin says.

One Lincoln student researched the antidepressant Prozac. She interviewed professors of pharmacology, created a dance that expressed the drug's effect on mood, and - to stretch herself in a weak area - spoke on the topic before a group. Another student studied caffeine. He extracted it in a chemical experiment, wrote about its role in

By cultivating a broad range of intelligences, teachers can uncover hidden strengths among students who don't shine at verbal or mathematical tasks.

Assessing learning through multiple intelligences poses a challenge ... should teachers allow a child to paint a picture or create a dance to show understanding of a concept?

our culture, and created a musical medley to convey the sensation of drinking one's first cup of coffee in the morning.

When schools honor multiple intelligences, students achieve more overall because they can draw on their strengths, Martin believes. When students receive accolades for their special talents, their sense of self-worth and comfort level are bolstered, sending them into an "upward spiral" of greater enthusiasm for school.

But even if teachers want to address all seven intelligences, it's natural to shy away from one's weaknesses. How can a teacher who is tone deaf help students develop their musical intelligence, or a teacher who is uncoordinated teach bodily-kinesthetic skills?

Teachers cannot escape their bias toward their own strengths, says Linda Campbell. Therefore, they must team with others who have expertise in areas where they themselves are weak. Teachers in a school should acknowledge their strengths and rely on one another, she advises. "We're not all Renaissance people."

Teachers at Skyview Junior High School act as "intelligence experts" for one another, DeGallier says. In planning how to teach a novel, for example, an English teacher might ask a science or math teacher, "How would you incorporate logic?" Teacher teams share a daily planning period, and the synergy among team members is "amazing," DeGallier says. "The ideas fly."

Teachers can also call on outside expertise. One Washington school coordinated parent volunteers to teach weekly enrichment activities, Linda Campbell says. Students could choose from a menu of topics, including gardening, cooking, music, and various forms of art. "It was not a one-shot but year-long effort," she says. Because the intelligences are so diverse, Bruce Campbell believes teachers should bring into the classroom a variety of experts - such as visual artists, musicians, and newspaper reporters - and coordinate apprenticeships, if possible.

Although tapping expertise is important, teachers should not always avoid using an undeveloped intelligence, experts say. By occasionally working outside their comfort zone, they can set a valuable example for students.

Multiple Assessments?

As teachers work to develop a wider range of student intelligences, assessment must also change, experts say. Relying heavily on paper-and-pencil tests "ropes kids back into a unidimensional concept of intelligence," Armstrong points out. "It's hypocritical to teach in seven ways and assess in one," he believes. "It sends a mixed message to kids." If teachers use varied forms of assessment instead, they will gather more diagnostic information and allow more students to successfully demonstrate what they know.

Assessing learning through multiple intelligences poses a challenge, however. Should teachers allow a child to paint a picture or create a dance to show understanding of a concept?

Linda Campbell believes it's feasible for students to demonstrate their learning in multiple ways, if assessment criteria are clearly articulated in advance. If students choose to write a song to show their understanding of air pollution, for example, the teacher should specify what the song must convey: major sources of pollution, its political implications, and potential solutions, for example. To define criteria to guide student work, teachers can develop rubrics for major curriculum units in collaboration with students, she suggests.

"We have to be willing to allow various methods of assessment," says DeGallier. He agrees that using rubrics can help teachers determine if students grasp a concept such as economic interdependence - whether students write an essay, create a diagram, or perform a skit to show what they've learned. Certain skills are intelligence-specific, however, and should be assessed directly, he says. If the objective is for students to learn to write a five-paragraph essay, then they should be required to write one for assessment purposes.

According to Gardner, "the important thing is whether you, as the teacher, can evaluate whether the kid does or doesn't understand" on the basis of the assessment. A promising approach could be to "co-interpret" the assessment with the student, he says. But teachers mustn't sacrifice their critical faculty just to allow flexibility.

Labels and Limits

Ways to apply Gardner's theory may vary, but educators are unanimous that multiple intelligences should not be used as labels that limit students' opportunities or their sense of their own potential. "When someone says, 'There's Sally - she's linguistic,' I just cringe," Gardner says, "because of the implication that that's the last word on the subject."

Linda Campbell is "very concerned about teachers labeling students and students labeling themselves." Teachers may fail to appreciate that intelligences can be enhanced and changed, based on need, motivation and opportunity. "Intelligence is dynamic and modifiable," she emphasizes. "Each intelligence has its own developmental timetable; some develop later than others," she adds.

If the theory of multiple intelligences is "misinterpreted," it could become the basis for another form of tracking, says Cindy Catalano, a teacher at Madrona School in Edmonds, Wash. Teachers must recognize that students' strengths change over time, she says, noting that she herself did not begin to develop her kinesthetic intelligence until college. Teachers should underscore that people have more than one strength, and give students experiences in all the intelligence areas.

While teachers should celebrate the areas where students are gifted, they should not "cut them any slack" in other areas, says DeGallier. For instance, students who are very kinesthetic but not verbal can't be allowed to use the excuse "I'm a kinesthetic person" to justify poor performance in English class. Teachers should not "shut down or demean" these students, DeGallier says, but encourage them to think, "If verbal-linguistic intelligence is lowest on my totem pole, then I have to work that much harder in that area."

Gardner says he is "delighted" that teachers are trying to translate his theory into classroom practice - an undertaking he considers "very hard". Often, he believes, applications of his theory are "more well-motivated than demonstrably effective." But if his theory prompts educators to reflect on teaching and learning, he's glad.

The appeal Gardner's theory has for educators is well expressed by Joan Sorenson, principal of Expo for Excellence Middle School in St. Paul, Minn. "If education deals only with the linguistic and logical-mathematic intelligences - if it sees the others as unimportant, as extras - then we miss out on a lot of what motivates and drives human beings," Sorenson says. Rather than ignoring certain intelligences, teachers should be calling them all into play to improve learning.

Scott Willis is a staff writer of ASCD Update.

Communication Apprehension: The Quiet Student in Your Classroom

Hilary Taylor Holbrook
ERIC Clearinghouse on Reading and Communication Skills

Communication apprehension is far more than the first stagefright frequently found in speech classrooms, school assemblies, and drama productions. It is a pattern of anxiety, established often in the elementary grades, which can profoundly affect much or all of a student's oral communication, social skills, and self-esteem. This digest examines some causes and consequences of communication apprehension and ways in which it can be diminished.

What is Communication Apprehension?

Communication apprehension (CA) has been defined as an "individual level of fear or anxiety associated with either real or anticipated communication with another person or persons" (McCroskey, 1977). This anxiety is a significant problem at the elementary school level. Research reveals that at least 11 percent of the elementary students experience severe CA, and an additional 20 percent may experience enough anxiety to warrant some sort of intervention (Harris, 1980; Garrison and Garrison, 1979; Wheeless, 1971).

Communication anxiety can be situational rather than pervasive in a child's behavior. "A tendency to be anxious when communicating may be specific to only a few settings (e.g., public speaking) or may exist in most everyday communication situations, or may even be part of a general anxiety trait that arises in many facets of an individual's life" (Friedman, 1980). Much research has dealt with CA in terms of a personality trait, but more recently the ideal of CA has expanded to include both trait and situation views (McCroskey, 1977).

What causes Communication Apprehension?

General personality traits such as quietness, shyness, and reticence frequently precipitate CA. According to Friedman (1980), when the ability and desire to participate in discussion are present, but the process of verbalizing is inhibited, shyness or reticence is occurring. The degree of shyness, or range of situations that it affects, varies greatly from individual to individual.

Seven factors which could result in a quiet child have been identified (McCroskey, 1980; Bond, 1984):

1 low intellectual skills
2 speech skill deficiencies
3 voluntary social introversion
4 social alienation
5 communication anxiety
6 low social self-esteem

Recognizing that Communication Apprehension is a frequent phenomenon that often occurs early in students' lives can be a spur toward eliminating many factors that contribute to the quiet child's withdrawal from communication.

7 ethnic/cultural divergence in communication norms

While CA is but one of these factors, the others can lead to CA. At the same time, their presence should not necessarily be interpreted as CA.

Another widely accepted explanation for CA is the Negative Cognitive Appraisal Model (Glaser, 1981). The model assumes that the quiet child was criticized for his or her early language performance. As a result, the child learned to expect negative reactions and subsequently learned to avoid them by keeping quiet. Even if teachers, parents, or other children merely appear to be reacting negatively to such a child's talk, the child will perform poorly and avoid oral communication situations (Bond, 1984).

What are the consequences of Communication Apprehension?

The consequences of CA are emotional, educational, and social. Shyness and reticence affect the social skills necessary for children to make friends. Shy students tend to confine their career aspirations to vocations that require little oral communication. They seem to have a higher need to avoid failure, and they have less achievement or success motivation than other students.

In the classroom, the teacher may regard quiet students as "perfect" in that they are not discipline problems. But often the CA students' lack of response or participation has a negative, spiraling affect - they are perceived as less capable, and are thus called on less frequently in class discussion. Their lack of enthusiasm tends to limit teachers' attention to them, which further reinforces their own self-evaluation (Richmond, 1984; Friedman, 1980).

How can CA be prevented or reduced?

The school environment can play a vital role in the prevention of communication apprehension. For example, thirty elementary and secondary teachers focused attention on the prevention of reticence, and identified several characteristics of a healthy classroom. These included

- creating a warm, easygoing climate in the classroom
- helping students get to know one another at the beginning of the year
- using drama and role-playing situations
- having students speak to the class in groups or panels rather than individually
- allowing students to work with classmates with whom they feel most comfortable
- having students speak from their seats rather than from the front of the room
- presenting students with oral activities in a developmental sequence

(Friedman, 1980).

Writing more specifically about the common "stage fright" type of CA, Suid (1984) suggests activities to overcome anxiety and improve presentation skills. These include informally questioning students concerning topics about which they are knowledgeable, reading speech transcripts and listening to master speakers, playing charades, presenting speeches without eye contact, and illustrating a speech.

To address the problem of CA on a somewhat broader level, Bond (1984) proposes a four-phase strategy:

1 Require teachers in training to take more than an introductory course in oral communication (e.g., a course aimed at understanding the communication behaviors of students)
2 Create basic communication courses in the earlier elementary grades
3 Provide specialized treatment for quiet/shy students on a voluntary basis
4 Develop classroom activities that encourage oral communication

The most commonly used treatment for CA in adults has been "systematic desensitization." This includes training in deep muscle relaxation, construction of anxiety-creating stimuli, and the graduated pairing, through imagery, of these anxiety stimuli with the relaxed state (Friedrich and Goss, 1984). Variations of these methods may also be effective for younger students.

In the classroom, the teacher may regard quiet students as "perfect" in that they are not discipline problems.

Preventing or alleviating communication apprehension for every student is a monumental if not impossible task. But simply recognizing that CA is a frequent phenomenon that often occurs early in students' lives can be a spur toward eliminating many factors that contribute to the quiet child's withdrawal from communication.

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Reversing Underachievement: Stories of Success

Student-centered enrichment projects guided by a caring teacher can help underachievers turn around the cycle of academic failure, a recent study indicates

Susan M. Baum, Joseph S. Renzulli, and Thomas P. Hebert

Bright underachieving students are often overlooked, especially in schools that serve at-risk populations. After studying 17 underachievers with high-academic potential, we've gained some insight into how the cycle can be reversed (Baum et al. 1994).

We use a prism metaphor to explain the process. Just as a prism takes in nondescript light and transforms it into colors, so does a student-centered enrichment process unleash the hidden potential of the underachieving student. The following vignettes will introduce you to three students who illustrate the complexity and diversity of the problem.(1)

Jamison

Jamison came from a dysfunctional family stricken with alcoholism and possibly child abuse. His time after school was totally unsupervised, and even his mother claimed "that school is his escape from our rocky home life." One afternoon, this 10-year-old was caught collecting money door to door for a local baseball team and then spending it on himself.

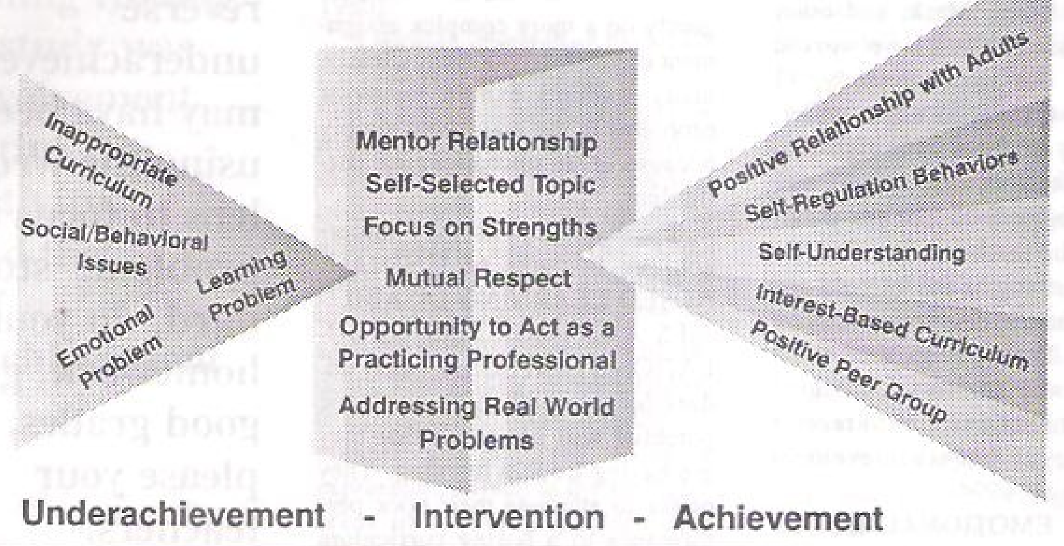
When screened for participation in an enrichment program, Jamison scored in the superior range on an individual intelligence test. Although Jamison's potential was apparent - his teachers noted his leadership skills, curiosity, keen observation, and divergent thinking skills - his grades had steadily declined.

For years, Jamison had been told that he was a distant relation of Abraham Lincoln, but his family had never provided him with the information to trace his ancestral history. His enrichment teacher, to whom he became very attached, assisted Jamison in his research in family genealogy. At her suggestion, Jamison wrote to the state archivist and, subsequently, received conclusive information that confirmed his belief. After completing his family tree, he presented a narrated slide show entitled "Jamison and Abe: 9th Cousins" to numerous audiences. Three local newspapers gave his presentations media coverage.

"This child has many strikes against him," Jamison's enrichment

FIGURE 1

The Prism Metaphor for Reversing Underachievement



commented, "but right now ject is meaningful to him. mportant, he and I have formed a bond that, I hope, will give him support and encouragement."

Mara

Mara wore white makeup and black clothing. She associated with youngsters who were suspected of using drugs. Mara and her 8th grade friends prided themselves on their negative attitude about school.

Because Mara could solve math problems without having to do computations, she assumed that she was a witch. Mara had difficulty understanding her intelligence, and her academic record had declined since 5th grade.

After Mara's failed attempt to arrange a limousine joyride for herself and a group of friends, her classroom teachers, counselor, and enrichment teacher suggested that she spend more time in the enrichment resource room. Through her involvement in an environmental project with other young women concerned about such issues, Mara began to think of herself as a leader rather than a follower.

After she completed a highly regarded photographic essay on the emotions of junior high school students, Mara's principal asked her to serve as an orientation guide for incoming students. Mara's grades improved, her peer group changed, and her white makeup and black clothing disappeared.

Mark

Lost in a shuffle was the best way to describe Mark, a bright, underachieving 8th grader. He stammered when he spoke and had facial scars from an attack by guard dogs when he was 7. Although he was musically talented, Mark felt inferior.

Mark's parents were both teachers and placed a high value on academic excellence. When Mark began to receive Cs and Ds in 7th grade - despite superior scc standardized achievement tes parents suspected an undia learning problem. Although he never overtly acted out, Mark resisted putting forth any effort to improve his grades.

At a school conference requested by Mark's parents, the enrichment specialist revealed Mark's interest in science and technology and volunteered to help him pursue his current passion: solar-powered vehicles. After visits with a community expert involved in designing solar-powered cars for a contest, Mark became enthused about entering the contest. Mark and his enrichment teacher met daily to design and construct his model car.

When the project was completed, Mark had gained self-confidence, his grades had improved, and he demonstrated a renewed sense of purpose. By his sophomore year, not only was Mark earning As and Bs, but his stuttering had also diminished.

Understanding Underachievement

What did we learn from Jamison, Mara, Mark, and other young underachievers we worked with? In our national study, 12 teachers, trained to assist underachieving students with high academic potential, selected 17 students - ages 8-15 (Baum et al. 1994). The teachers identified the students' strengths and interests and assisted them in developing creative projects. The findings shed some light on why students fall behind in their studies and how to reverse the cycle of underachievement (Baum et al. 1994).

First, EMOTIONAL ISSUES contribute to underachievement. For example, Jamison acted out to gain attention, exhibited behavior problems in school, and failed miserably in his academic work. Once he received positive attention from a caring adult, however, his achievement improved. Mark's problems stemmed from his lack of confidence and his physical disfigurement. After realizing his talent as a designer of solar cars, his stuttering disappeared and his schoolwork improved.

A second reason for underachievement is PEER GROUP PRESSURE. Mara's need to be accepted by an undesirable peer group led to her negativity and academic failure. As her photography project evolved, this creative young woman gained considerable attention from a new peer group, who valued academic achievement. As a result, her need to underachieve as a way to gain popularity was no longer necessary.

THE LACK OF AN APPROPRIATE CURRICULUM is a third reason for underachievement. All students in our study began to experience success when encouraged to pursue an area of interest in their preferred learning style. For instance, an 8th grader who refused to apply himself in social studies class was motivated to work diligently on a more complex assignment of his own choosing. Clearly, many students exhibit behavior problems in the classroom simply because of an unchallenging curriculum.

Finally, students may underachieve because of UNDIAGNOSED LEARNING DISABILITIES AND POOR SELF-REGULATION STRATEGIES. Many underachievers with high academic potential will not admit that they are having trouble learning. They prefer to attribute their poor performance to a boring curriculum or an unresponsive teacher (Baum et al. 1991). Once they pursue a self-determined goal, however, they are more willing to admit that poor learning strategies hinder their progress.

Reversing the Underachievement Pattern

The most compelling finding of our study was that involvement in creative productivity reversed the cycle of underachievement. Of the 17 students, 14 improved academically during that year and in the year following the intervention.

The few studies that have examined curricular approaches (as distinct from counseling and therapy) that are effective with high-ability underachievers have several important points in common. Unlike remedial approaches or traditional admonishments ("Learn how to get organized, and you will achieve" or "Work hard, and you will be rewarded"), the successful approaches tend to center on students, accentuate students' strengths, and value their interests. Several of these studies report that completing a meaningful project

Past efforts to reverse underachievement may have been using the wrong lens to focus the problem: study hard, do your homework, get good grades, and please your teachers.

The most compelling finding of our study was that involvement in creative productivity reversed the cycle of underachievement.

increases self-esteem, academic self-efficacy, and overall motivation (Baum et al. 1989, Baum and Owen 1988, Emerick 1992, Whitmore 1980).

Likewise, research on high-ability students, in general, indicates that allowing students to pursue topics of personal interest and in their preferred styles of learning often results in high levels of achievement. The TOTAL TALENT PORTFOLIO, a planning matrix, provides guidance for examining the full dimensions of students' strengths by calling attention to interests, instructional style preferences, and preferred modes of expression, as well as the strongest areas of academic performance (Renzulli 1994). We have learned much about applying this type of learning experience with youngsters of all abilities and providing them with the guidance necessary to carry out advanced-level projects. The Portfolio is a major component of the ENRICHMENT TRIAD MODEL (Renzulli 1977). This model provides students with: (1) general exploratory experiences that might stimulate a new area of interest; (2) authentic research skills and learning-how-to-learn skills that are necessary for pursuing an interest in greater depth; and (3) guidance in the pursuit of individual and small-group investigations of real problems that are designed to have an impact on a real audience.

The goal of what we call Type III Enrichment is for students to investigate real problems through authentic means of inquiry and present their findings to real audiences. Students collect raw data, apply advanced-level problem-solving techniques, and use the research strategies or artistic procedures of firsthand investigators within various fields of study. Detailed procedures and resources for guiding the investigative process have been widely field-tested over the years and provide teachers with a systematic set of strategies (Reis 1981, Delisle 1981, Gubbins 1982, Burns 1987).

The role of the teacher is crucial to the success of this approach. Teachers who are most effective in reversing the underachievement pattern

- take time to get to know the student before initiating an investigation;
- use their time with students to facilitate the process rather than counsel them regarding their underachievement;
- see their role as a facilitator of the process - for example, by arranging frequent student/teacher conferences, providing resources, allocating school time for students to complete the project, and making suggestions when students seem to be at a standstill;
- understand that students need to act like practicing professionals and share their products with real-world audiences;
- recognize the dynamic nature of the underachievement problem by observing students, reflecting on their behaviors as they work on their projects, and identifying strategies to help students overcome problems;
- consistently demonstrate patience and believe in the student!

The Prism Metaphor

Past efforts to reverse underachievement may have been using the wrong lens to focus the problem: study hard, do your homework, get good grades, and please your teachers. The approach described here suggests a prism metaphor (see fig. 1). Whereas real images are formed when rays of light are reflected in a mirror, something quite different happens when a ray of light is passed through a prism. Not only does it change direction, which is the goal of reversing underachievement, but it also takes on qualitative differences. The result is a spectrum of color that is critically different from the light energy that originally entered this special environment. This mysterious phenomenon is similar to one observed when students pursue their own investigative experiences.

Although no formula can be prescribed that is appropriate for all students, we believe that the complex blending of effects that occurs within the context of enrichment experiences - much like a prism - helps explain the transformation of underachievers into confident, successful students.

(1)Jamison, Mara, and Mark are pseudonyms.

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Transforming Ideas for Teaching and Learning Science

A Guide for Elementary Science Education

Office of Educational Research and Improvement
US Department of Education

When you see..
That flowers don't grow when it snows,
That all kites need a wind that blows,
Some birds are red, some blue, some brown,
And a wheel, to roll, must be round,
That's science.

(Evelyn Smith, Kindergarten Teacher, as quoted in McIntyre, 1984)

Bringing state-of-the-art science instruction to students in grades K-8 is a high priority. There is a greater appreciation of the fact that if we are going to bring quality science education to all students, produce science literate citizens, and meet the national education goal to be first in the world in science achievement, we must begin with the early school experiences of children.

A comprehensive reform of the science curriculum, and ways of teaching and assessing science instruction, is underway. This reform has been characterized as "deep, widespread, and serious." It is systemic, requiring that all parts of the system be partners in change. It is occurring at the national level, in the states, in schools, and in individual classrooms. Teachers, as well as administrators, policymakers, and community members, have a vital role to play in furthering reform. To truly change science education, a widespread effort is required.

This reform builds on the experience of the post-Sputnik activities of the 1960's and 70's, with a strong emphasis on development of new curricular materials following a discovery or inquiry approach. Studies have shown that the new curricula were generally more effective than traditional programs in improving student performance on cognitive measures and raising attitudes about science. But they did not get into the classrooms and did not have the benefit of the more recent insight into children's need to make sense of science. Developments in cognitive sciences in the last decade have provided new perspectives on learning that have major implications for instruction and serve as a research base to drive the current reform.

There are some promising new curriculum projects which have been developed to take advantage of recent knowledge of how children learn. For example, the National Science Foundation has recently supported major elementary school materials development programs (National Science Foundation, 1993). Some of these have an interdisciplinary emphasis as well, and some involve technology following a science/technology/society focus. Other promising elementary curriculum programs are under development that encourage understanding of scientific concepts. Museums and other informal science education resources which often include classroom materials are readily available to teachers.

A part of the new approach stresses less coverage of topics to achieve greater depth of understanding. But this approach assumes that science instruction will be prominent in the curriculum of primary and upper elementary grades. It takes time for students to develop understanding in this new way of instruction.

The U.S. Department of Education would like to share ideas drawn from research and promising practice in science education. These ideas are addressed specifically to educators, but we believe they are important to anybody concerned with science education in elementary, middle, and junior high schools. They include families and other concerned adults, as they have an important role in our children's science learning and can provide support at home and in the community for improved science education.

Science is for all students

> Elementary science education is a key to the basics because science promotes the development of the thinking skills, learning processes, and positive attitudes required for lifelong learning.
>
> *(Mechling and Oliver, 1983).*

A change in the goal of science teaching from preparing a few students with an interest in and an aptitude for scientific professional careers to educating all students in the science needed for today's world has transformed the way we think about science education. All of our children and young adults, not just those preparing to be professional scientists, must have an understanding of the science and technology behind the various social issues affecting their lives.

Yet, science has remained a relatively low priority in elementary school for many years, while reading, writing, and arithmetic were considered the basics. A 1990 National Assessment of Educational Progress (NAEP) survey indicates that fewer than one-half of the fourth grade students attended schools that gave special priority to science, compared to three-fourths or more who attended schools that gave special attention to mathematics, reading, and writing. The fact is that science is not taught frequently in many schools. Twenty-eight percent of the fourth graders reported having science instruction about once a week or less frequently, and only about one-half reported having science instruction every day.

The elementary grades are a critical time for capturing children's interest. If students are not encouraged to follow their curiosity about the natural world in the primary grades, waiting to teach science on a regular basis in grade four may be too late. Data show that many children tend to lose interest in science at about the fourth grade. Quality science instruction at the upper elementary grades is also important, for at present these grades are the last time that science is a part of the regular curriculum for students.

Setting science standards provides a valuable resource for improved instruction.

> American education will be well served by an organized attempt to provide direction on a nationwide basis and to determine some of the important skills and knowledge that all students should master at key stages in their education, without trying to specify a national curriculum.
>
> *(National Council on Education Standards and Testing, 1992)*

To transform science instruction nationwide, reaching schools in the various districts and states, there needs to be agreement on what students ought to know, how it should be presented, and how to measure the results. The setting of science standards is underway through the work of the National Academy of Sciences through its National Research Council working with the American Association for the Advancement of Science, the National Science Teachers Association, and other professional scientific societies and the broad constituencies they represent. Working groups are drafting standards for curriculum, teaching, and assessment. A consensus process is being followed to encourage broad review and discussion of the products of the groups with a final version planned for late 1994.

Rigorous standards will set the framework for what young Americans should know and be able to do when they leave school. States are making crucial systemic changes to reach these standards, including developing curriculum frameworks, improving assessments, and revising teacher certification and licensure requirements.

Research studies show that children who are in schools with high expectations and challenging curricula learn more than children who are in less demanding educational programs. Most students will work to meet whatever expectations their teachers and families have for them, however high, however low. In science, as in other important subjects, we need a clear consensus on what students should know.

The Statement of Principles on School Reform in Mathematics and Science from the U.S. Department of Education and the National Science Foundation states that "all children should receive a challenging education in mathematics and science based on world-class standards beginning in kindergarten and continuing every year through grade 12."

Students learn by "constructing" knowledge.

Constructivism tells us that people have to build their own scientific knowledge and understanding and that, at each step in science learning, they have to interpret new knowledge in the context of what they already understand.

> We cannot teach directly, in the sense of putting fully formed knowledge into people's heads; yet it is our charge to help people construct powerful and scientifically correct interpretations of the world. We must take into account learners' existing conceptions, yet at the same time help them to alter fundamentally their scientific misconceptions.
>
> *(Resnick and Chi, 1988)*

Research from the cognitive sciences and from science education has transformed our understanding of how children learn. The view of the student absorbing knowledge, called the "constructivist approach" by being involved in interpreting and understanding new content, and linking new knowledge to existing knowledge in a meaningful way.

Learners come to new situations with preconceived notions; they are not blank slates. As children develop, and long before they enter formal education, they need to make sense of the natural world about them. Thus they begin to construct sets of ideas, expectations, and explanations about natural phenomena. Since these ideas are frequently quite different from the ones held by scientists, we sometimes refer to them as naive conceptions. For example, fifth grade students were asked, "What is food for plants?" Most students gave replies of "water," "soil," or "plant food" that can be bought in stores. These students had the idea that food for plants was something similar to food for people, rather than plants' need for light to make their own food through the process of photosynthesis (Anderson and Smith, 1984).

But the students' ideas make sense to them even though they are wrong from a scientific perspective. Naive conceptions are strongly held and must be examined and challenged in the course of instruction for new understanding to develop.

Teaching for conceptual change or "teaching for understanding" as it is called, required different strategies from those usually followed in the classroom. Teachers continually diagnose student ideas and consider where they are in the process of conceptual change. Students' naive conceptions are addressed through exploration and discussion. Opportunities are provided for testing of ideas, even those that are false. Materials are needed that will encourage the student's exploration of a phenomenon as a way of acquiring new knowledge. While research continues on the implications of constructivism for the curriculum and instruction, there is agreement that traditional didactic teaching is not the most effective way to promote conceptual change because students often remain committed to their alternative conceptions while memorizing new material and doing well on tests, but without any real understanding of new concepts.

Hands-on, inquiry-based science instruction is well-established as an effective teaching strategy.

> Hands-on science means just that - learning from the materials and processes of the natural world through direct observation and experimentation. Professional scientists develop hypotheses and than test these ideas through repeated experiments and observations. They cannot simply "know" that something is so; they must demonstrate it. The education of children in science must also provide for this kind of experience, not simply to confirm the "right" answer but to investigate the nature of things and arrive at explanations that are satisfying to children and that make sense to them
>
> *(National Science Resources Center, 1988)*

Hands-on learning activities used appropriately can transform science learning by engaging the student in the process of science. Unfortunately, these activities are not widely used. It could be because so few teachers have had opportunities to develop skills needed for hands-on instruction. Another factor is that "hands-on learning takes time - and the pressure to get on with the overstuffed curriculum discourages many teachers from taking that time"

(Rutherford, 1993).

In hands-on science instruction the teacher engages the students in questions that require them to think about and apply what they are doing to new situations. The "minds-on" part of instruction comes with dialogue, discussion, and exploration using the hands-on materials. Experiences with a particular science phenomenon must be concrete, relevant to the students, and varied.

All hands-on activities include materials. The student learns by doing, using materials such as plants, batteries and bulbs, or water, or instruments such as the microscope, meter stick, or test tube. But instructional materials must be sequenced to facilitate students' construction of meaning. Giving students sets of activities without connections drawn among them leads to isolated bits of knowledge or skills which do not promote understanding but rather the forming of naive conceptions. Therefore, rather than presenting students with bits and pieces of information and leaving it to them to piece these together, the teacher needs to help students see the interconnections among scientific ideas.

In practice, however, despite the emphasis on "doing science" with the use of instructional materials, textbooks have defined the curriculum. In drawing a comparison one science educator commented: "Teaching with hands-on activities is demanding, but everyone is involved, eager, and active, and participants remember what they have done... I never saw a textbook do that" (Rosanne Fortner, as reported in Haury and Rillero, 1992). While textbooks may have a place in the curriculum as a support to inquiry and experimentation, a more experimental base is needed at all levels involving use of instructional materials and equipment and thought-provoking questions and dialogue.

Other material resources are needed to support students' exploration of scientific ideas. Children's trade books and magazines are valuable resources to engage students and enrich their understanding of the natural world. Many of these resources are reviewed and evaluated periodically and an annotated bibliography is published as a guide for users. Relevant films, videos, and computer resources are also important resources for the classroom. In addition, technical support is needed to supply teachers with science equipment and materials and to maintain and manage these resources.

Exploration, dialogue, and discourse promote understanding.

> As Socrates well understood, learning is more likely to change through dialogue and reflection than through lecture and imposition.
>
> *(Kober, 1993)*

> Not only do children need to amass direct experience with natural phenomena, they also need time to accommodate their experience by talking about it with their classmates and their teachers.
>
> *(The National Center for Improving Science Education, 1989)*

Learning is interactive and occurs in a social context. The vision is to transform the classroom into a learning community where ideas are shared, evidence is used to strengthen ideas, and there is willingness to change ideas through exploration, dialogue, and discourse.

Teachers should provide students with many opportunities to explore scientific phenomena, using examples from their everyday experience. Exploration allows students to "play" with materials and ideas in open discussion with others. Through exploration students apply their naive understandings and develop explanations by experimenting. It is also a way for students to confront their misunderstandings.

Teachers organize the classroom and set the social norms of discourse to help students develop understanding from experience with materials in the classroom as well as from their out-of-school experiences. As one science educator described it: "There must be opportunity for independent exploration, as well as guided group activity, for quiet reflection and for animated discussion. Small group work enables every individual to participate fully in activities and discussion, and allows children to develop leadership skills, to learn from one another, and to take intellectual risks" (Bird, 1992). Research on cooperative learning indicates several positive effects of small group, student involved or led, hands-on science lessons. However, for small group cooperative learning the teacher must carefully plan the learning environment; "... it takes time and practice for teachers to become skilled in its use" (Blosser, 1992). Large group work brings students together to share a variety of ideas similar to professional scientists collaborating on an investigation. Through a combination of large group and small group work the teacher designs the classroom environment to promote experiential learning.

Discussion among a small group of students or between student and teacher, and the framing of ideas and arguments to support a particular point of view, is an important strategy for developing students' conceptual understanding. Every effort should be made to have children ask questions and then use their questions to further their investigation. By posing questions, teachers may assist children to confront their assumptions and lead them to follow new paths of inquiry.

Instruction should focus on the essential key concepts or ideas of science in the overfull science curriculum and on teaching them more effectively.

> Curricula must be changed to reduce the sheer amount of material covered; to weaken or eliminate rigid subject-matter boundaries; to pay more attention to the connections among science, mathematics, and technology; to present the scientific endeavor as a social enterprise that strongly influences - and is influenced by-human thought and action; and to foster scientific ways of thinking.
>
> *(American Association for the Advancement of Science, 1989)*

A transformation in science curricula is occurring from coverage of a large number of facts and terminology on many topics to more indepth study of fewer, major concepts. Major scientific ideas or concepts and thinking skills need to be emphasized while somewhat less attention should be paid to specialized vocabulary, memorized facts, and procedures. Both *Project 2061* of the American Association for the Advancement of Science and the National Science Teachers Association's *Scope, Sequence, and Coordination* project recommend that instruction cover the main ideas of science and the interrelatedness among various phenomena within the disciplines. The goal is to provide a greater depth of understanding.

There are different schemata for organizing science content around topics and relating units often taught in elementary grades to the larger ideas of science. *Project 2061* identifies common themes that pervade science, mathematics, and technology (such as systems, stability and change, and scale) and suggests that science curricula should be centered around these themes. A conceptual approach to science would suggest science concepts (such as diversity, variation, order, structure, function, and change) as a way of integrating diverse topics. Other reports suggest different organizing principles, but the common element from research and studies is that the curriculum highlight major ideas, concepts, or themes, "the big ideas," so that "detailed information about science becomes connected, becomes meaningful, and contributes to successful problem solving" (Elementary School Science for the '90s).

More time can be spent on developing understanding of the major concepts illustrated by the topics. An illustration of how a unit on seeds can build understanding of a major idea is found in the Life Lab Science program. The first grade theme of this curriculum is diversity and cycles. A unit on investigating seeds would compare and contrast seeds, monitor germination, and begin to predict the outcome of simple experiments. Other units on a study of soil and the diverse plants and animals living in it will continue the theme drawing upon the life, physical, and earth sciences and the connectedness among the sciences around this major idea.

The teacher's role is changing to facilitate student learning, while the student becomes a more active learner.

> The role of the teacher ... requires much skill and effort. The teacher needs to identify projects that will interest students, monitor their work by asking questions that will further the work, help them learn how to work together. We need to allow students to be the children they are, to allow them to play and explore phenomena of interest. We need to avoid or reduce a fear of being "wrong," and encourage their delight at the unexpected. Children's curiosity, whetted by the clever teacher, needs to become the impetus for much of their work on science projects.
>
> *(Trumbull, 1990)*

The role of the teacher is being transformed from one of primary dispenser of knowledge to one of being a facilitator of learning. This is a more demanding role in many ways. The teacher provides information in the context of a rich learning environment, in which the student is an active learner. Rather than the teacher telling the students what they are to learn, the teacher sets up an environment where the student can be active in acquiring knowledge, mainly through the process of experimentation and discourse.

The teacher engages students in problem solving by asking probing questions, promoting inquiry, and guiding discussion with use of hands-on materials. Facilitation also takes being well acquainted with resources-whether they be curriculum materials, technology, community members or professional colleagues with special expertise, or institutional resources such as museums or science centers, and a capacity to draw on these resources as the need develops. "When students' investigations lead them down an exciting but unexpected path, having experimental materials or reference tools at hand or having a knowledgable colleague to call on can turn a 'teachable moment' into a lifetime of understanding. Good teachers are accustomed to responding to children's short- and long-term intellectual and emotional needs, but to do so in the context of scientific inquiry requires a special kind of preparedness and sensitivity" (Bird, 1992). It takes a deep understanding of basic science concepts and a willingness to not always be the "authority" to be comfortable teaching science in an experimental mode.

For teachers to be successful facilitators of children's science learning, a great deal of support must be made available to them both within the school and from the broader professional community. They cannot do this without support from professional colleagues. They must have opportunities to exchange ideas and experiences with other teachers and with colleagues from the science and education community, to reflect on their teaching, to read research and contribute to it as part of a research team.

Appropriate staff development brings lasting improvements in science teaching.

> Staff development programs that result in meaningful changes in teachers' behaviors have certain common characteristics. Among other things, they allow for intense study of and engagement with the new knowledge or skill over time, with time to practice and work through with others the problems of implementation. This combination of theory and application, time to reflect and practice, self study and cooperative learning, rarely is found in the more traditional inservice workshops, college courses...
>
> *(Loucks-Horsley and associates, 1989)*

The teacher is key to improved instruction. Since teaching for understanding demands a role that the teacher's preservice training often did not model, opportunities for inservice training are essential in transforming science instruction. In addition, teachers are often minimally prepared in science content, particularly elementary teachers who must teach all subjects. While very capable, teachers often have not had a college program that provided a basic background in the physical, life, and earth sciences and the ways to teach science to promote understanding.

Elementary school teachers do not need to be experts in every aspect of science; in fact most scientists are experts in only a narrow specialty. But they do need a general background in science content.

It is most important that the inservice instructors model the teaching strategies they wish teachers to use. In addition, time for the teachers to practice new teaching behavior and continue to work with mentor colleagues is also a part of a good inservice program. Further, teachers will need to have regular opportunities to plan and collaborate with their fellow teachers at professional meetings such as national and state science teachers' meetings.

Teaching for understanding takes not only time to learn but also support from other colleagues and the school administration. Meaningful change in teacher behavior may take years. Teachers experimenting with new strategies and programs need the time and resources to try new techniques to determine what works best. They also need to exchange ideas. In short, they need to use the same methods to learn to teach science as the students need to learn it.

The most effective staff development activities:

- are continuous and on-going;
- model the constructivist approach to teaching that teachers will use with their students;
- provide opportunities for teachers to examine and reflect on their present practices and to work with colleagues to develop and practice new approaches; and
- provide good support structures within the group, among the group and the instructors, and from the school.

Assessment must be more closely aligned with the goals of science instruction.

> Perhaps the most compelling reason for developing performance assessments is that they can provide an opportunity to appraise what society currently values, but is having difficulty measuring with multiple choice tests. Whether one reads a science journal or the Wall Street Journal, there are pleas for educating students who have both the mastery of subject matter knowledge and the more general abilities to think, solve problems, communicate, and collaborate.
>
> *(Baron, 1990)*

A view of assessment as the servant, not the master, of curriculum is transforming assessment practice. Assessment and instruction are closely linked. Since teachers experience pressures to teach to the test, the prevalence of assessments that do not test for conceptual understanding or are limited to isolated facts has led to a curriculum that focuses on factual knowledge and vocabulary. In this way, students learn discrete pieces of information and unconnected facts.

A new link between assessment and instruction is being forged through the reform movement. By using more authentic assessments such as performance-based or portfolio assessment or multiple choice tests that require thought beyond recognition and recall, more higher order thinking skills can be assessed, and students can learn through the process of assessment itself. Children must be offered many different options for communicating what they know and understand, and for raising new questions about a subject. Occasions to demonstrate ideas, quantify results, and make written, oral, or visual presentations of findings and hypotheses are essential. The important consideration is that the assessment measure progress toward the goal of the instruction.

Families and other concerned adults play important roles in promoting science education.

> Informal science education resources also can provide a strong foundation for learning science. Like many of you, I have always enjoyed visiting zoos. As a youngster, I didn't visit zoos to learn about animals. I went simply to see animals and to have fun, but I learned about animals in spite of my non-academic motives.
>
> *(Druger, 1988)*

The rise in informal science education opportunities and the strong influence of the family and other adults on children's science learning has the potential to transform science learning. Families and the community can encourage children's study of science both in school and in out-of-school, informal science education activities. They can do this by supporting children in their homework, carrying out science activities at home, and participating in the growing number of informal science activities at zoos, museums, nature centers, national parks, and community organizations such as 4-H clubs. If families view science as an important subject for all students, they will more likely promote science activities for their children both in school and out of school. Often parents and other members of the community can bring their experience to enrich the curriculum.

The availability of informal science education activities for young people has increased dramatically in the last few years. They vary in format from Science By Mail, a program produced by the Boston Museum of Science, to the "Voyage of the Mimi" televised science program. Other programs help adults and children work together on science in out-of-school activities. The Family Science Program from the Lawrence Hall of Science at Berkeley encourages fun with science as a family activity. The U.S. Department of Education has published the book *Helping Your Child Learn Science* with many excellent opportunities to engage children in science.

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