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INTERNET APPLICATIONS IN CLASSROOM LEARNING

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At Stevens Institute of Technology, we are fortunate to have been able to explore applications of Internet in K-12 science classrooms during the past six years. With U.S. government funds from the National Science Foundation and the U.S. Department of Education, we have been working with more than 5,000 teachers in New Jersey, Ohio, Arizona and Florida.
All educators search for ways to make learning more engaging, to increase student motivation, to elucidate difficult concepts, and to link students in isolated classrooms with the vast resources of the outside world. We have found that with the Internet knowledgeable, thoughtful teachers in supportive school environments are able to achieve many of these elusive objectives. However, results cannot be achieved without careful preparation and planning. Specific Internet resources must be identified, curriculum matches must be made, cognitive development must be nurtured, opportunities for exploration must be guided and excellent lesson plans must be developed.

Compelling Attributes of the Web. In promoting classroom applications of Web technology, we have sought to emphasize use that is unique, compelling and not easily duplicated with any other technology. With this point of view, we have discouraged Web applications that could be easily implemented using a CD-ROM or software. While the Web can be a convenient and economical vehicle for delivery of text, images or software, we have preferred focusing on attributes that allow exploration of learning opportunities.

We have found that the exciting opportunities for Web use in classrooms are those that engage students in acquisition of real-time data, in communications with peers and with access to experts. Experience with constantly changing sources of information and dynamic human interactions beyond the classroom walls, not only motivate students but open important, new possibilities for science study.

By working with real-time data students can "do" science instead of reading about science as has so often been their experience with text-book based lessons. Real-time data allow students the opportunity to investigate an issue, to draw inferences, to develop hypotheses and then to test their conjectures through the analysis of new data. In the United States, new National Science Education Standards* push students to no longer just memorize facts and figures but to apply these to solve real world problems. The Internet can equip educators with a new dynamic teaching tool to meet that challenge. This "blackboard for the 21st Century" can supply the classroom with real world scientific

*National Research Council, National Science Education Standards, National Academy Press, Washington, D.C., 1996.

data, communications with peers and scientists from around the globe, as well as real time data from scientific instrumentation such as satellites, telescopes, and microscopes all of which make science real for students.

Real-time data can be generated in various ways for transmission via the Web. Our experience can be summarized in terms of three basic mechanisms. We find that data can originate from:

- measurements of peers at remote locations
- publicly available Web sites
- instrumentation in scientific laboratories.

Peer developed data is usually transmitted during a collaborative project. The Web is particularly valuable in this context in providing types of data from remote locations that are not available locally. Examples of successful collaboratives that we have conducted include: investigating relationship between the boiling point of water and elevation; observing inherited genetic traits in large populations; water quality measurements from regions around the world; investigating the relationship between average weekly temperature and latitude, and investigating the effects of warm ocean currents on the climate of remote land masses.

Publicly available Web data that we have utilized includes: satellite observations of weather, ocean conditions, and land conditions; volcano data; earthquake data; data from ships at sea; oceanographic instrumentation; and Environmental Protection Angency (EPA) air quality data. In collaboration with the Waksman Institute of Rutgers University there has been particular success in having students tackle challenging problems in molecular biology and genetics which have required them to access on-line genome data bases.

Instrumentation in scientific laboratories has been promoted in our project through two especially noteworthy initiatives. In collaboration with the Princeton Plasma Physics Laboratory we have make real time fusion research data available to students and in collaboration with the Stevens Material Engineering Laboratory we have provided students with customized images of their own samples from a research quality scanning electron microscope.

Surfing by Teachers. In preparing teachers for use of the Web in their classrooms, we have found that simply providing teachers and students with technical facility for using and searching the Web is not enough. It is a fallacy to think that skill with surfing is sufficient for educational improvement. In fact, surfers can become overwhelmed and confused. To think that surfing abilities necessarily lead to better teaching and learning is like thinking that all teachers who learn word processing will then be able to write meaningful text books! It takes a great deal of time, effort and knowledge of Web resources, pedagogy and science content for an individual to enrich classroom experience. While some teachers can certainly do this, it is a challenge for most – particularly at the pre-high school level where science content preparation has not been strong in American colleges of teacher education.

Even when lots of knowledge and skills come together, it is important for materials to be tested in various classroom settings and for the science content to be reviewed by an expert. Often, Web materials are in domains that are somewhat new to teachers and care must be taken to validate the science underpinnings. These testing and review opportunities are often difficult for classroom teachers to implement. Therefore, it is important for there to be resource centers where collaboration and consultation are possible.

School System Support. Web based education is critically dependent upon teachers having a technological infrastructure which supports their efforts. While a great deal of publicity has been given to total wiring of school buildings, we find that it is important for schools to get started with pilot projects before embarking on ambitious technological development efforts. With just one computer and modem in a classroom, a trained teacher is able to accomplish a great deal. This basic configuration, which is an excellent starting point, is absent from many classrooms in America.

Teachers need to know how to handle potential problems with connectivity. Most teachers cannot afford to miss a lesson because an Internet Service Provider was not operational. To obviate such possibilities, we have emphasized the need pre-load web sites prior to classroom use, have alternative back up plans, and use software such as Web Whacker to save static web pages.

A more fundamental issue is that teachers need to have strong school system support for installation and maintenance of technology as well as time and resources for curriculum development. The most effective model that we have experienced is that of having master teachers who are sponsored by the school system. These master teachers then promote technology integration in specific classrooms with the full support and authority of the central administration. Beyond curriculum support, school systems must recognize the importance of providing reliable technologies to their staff and faculty. If a teacher cannot depend on a technology working as reliably as a textbook or a blackboard, they are unlikely to use it. School systems must dedicate funding to hire the necessary support staff to maintain Local and Wide Area Networks, computer labs, software and hardware as well as Internet services.

Curriculum Examples

Many of our curriculum activities can be found at our Web site:

`http://www.k12science.org.`

Some specific examples that illustrate some of the concepts presented are detailed below.

A Water Quality Collaborative. Three years ago, an 8th grade science class in Jersey City, New Jersey learned about ecosystems by reading about them in their textbook. Today, with the addition of new microscopes and an Internet account, students visit a local fresh water pond to collect samples and analyze them under the microscope. Through the Internet students established communication with classes in Japan, South Africa, and England who were conducting the same investigation. They considered the question, "Will you find the same organisms in the water in these other locations that you do in Jersey City?" Students hypothesized and made predictions about the organisms living in the water in the three locations, and were able to observe, through pictures posted on their partners schools' home pages, that the very same creatures did, indeed, exist in all four sites.

While our efforts have been directed at science topics, we have found that Web-based implementation often leads naturally into multi-disciplinary learning activities. In the process, students exchanged email about themselves, their culture, and current events. A notable exchange took place with two separate groups of students in South Africa. One group was advocating attention to a common culture for South Africa, while another group advocated the preservation of certain native traditions. This was an educational experience that would be hard to implement in any other fashion. It stimulated the Jersey City students to engage in very active dialogue with their new found friends. The teacher reported that, for the first time, she had to ask her students to stop writing so much!

In 1998 the Baba Tonka Secondary School of Mathematics in Rousse, Bulgaria, participated in a Stevens Global Water Sampling Internet collaborative project. Their final report can be found at:

`http://www.ciese.org/curriculum/waterproj/F98reports.html`

On-Line Data from Ships at Sea. Hundreds of ships in the world's oceans regularly report their precise location along with basic information about weather and sea conditions. These data can easily be obtained from a data base maintained by the National Oceanographic and Atmospheric Administration which updates the information several times each day. While this volume of information can be overwhelming, we have found it provides an exciting way for students to engage in vicarious travel. By pretending they are frightened stowaways on a ship, fifth grade students can try to determine the location of the port to which their ship is bound. They are assigned by teachers to particular ships and reminded that they, of course, have lap-top computers and cellular telephones. Using sequential reports of location, Internet resources can be employed to calculate the speed and direction of the ship. With this information, estimates for arrival at a port city can be determined. Parents can then be called and asked to pick them up. This type of activity allows students to apply facts, such as the equation for the speed of an object, to real life situations which gives them a context for learning that other technologies simply cannot supply.

This has been an engaging experience for many students. Questions have arisen about the cargo of these ships. We are beginning to obtain information about the role of individual ships in international trade. Limited experience is now being gained in which we have arranged for students to be in direct e-mail contact with the senior staff of major cargo vessels. This new dimension to the project has given participating students the chance to communicate directly with professionals in industry, have their work checked, and engage in scientific conversations about weather conditions. The response from both the students as well as the officers onboard the vessel has been tremendous, we hope to expand this to a school wide project.

An extension of this unit that is used with seventh and eighth grade students involves their wishing to stay on board the ship and accepting a work assignment in order to justify their continued passage. The job that they are assigned is to be the Internet weather advisor to the captain. The students then track the progress of the ship and monitor weather conditions from real time satellite sources to determine if there is a need to change the course.

Merchant ship data for the Mediterranean and Black Seas can be found at:

`http://www.oceanweather.com/data/eatl.html`

International Boiling Point Project. Also in 1998, students from the Academician Kiril Popov School in Plovdiv, Bulgaria, participated in an Internet collaborative project on the boiling point of water. Their final report can be found at:

`http://www.ciese.org/curriculum/boilproj/bulgariareport.html`

Student Use of a Remote Scanning Electron Microscope. Powerful optical and electron microscopes at university and research centers can be made available for use in schools via Internet technology. Remote use of telescopes has already been developed for classroom use. A microscope initiative is being developed at Stevens as a prototype of what can be accomplished through remote access to scientific instrumentation. Electron microscopes can make images accessible to classrooms with magnifications that previously were only available to research scientists. At Stevens we have provided students with opportunities to submit samples of airborne particulate matter from their schools for electron microscope analysis. These samples were processed by graduate students who were in contact with the submitting high school via CU-Seeme Internet two-way video. The students were able to see how the electron microscope was operated and were able to get direct access to the resulting images. By reviewing images with magnifications of 3,000x to 10,000x which were compared with reference images, students were able to identify chalk particles. This type of activity helps students understand concepts of size and scale and is directly relevant in terms of understanding the new EPA air quality standards that call for control of particles down to a size of 2.5 microns.

There are many instruments that are used in science laboratories that could be made available to K-12 students through the Internet. This mode of exploration and discovery can also profit from collaborations that bring college students, graduate students and scientists into direct contact with K-12 classrooms. New opportunities for science education will undoubtedly proliferate along these lines in the near future.

Web Publishing. Posting students' work onto a web site is today's equivalent of a science fair, where parents, teachers, and community members can see students' projects. Teachers report that when students know their work can be seen by distant friends and relatives and others around the world, they are motivated to do their best. Project work is also another means of evaluating student achievement and provides teachers with additional information about students' accomplishments beyond test scores.

Future Prospects. We can see from current R&D activities in the computer world that Internet and the Web will undergo significant changes in coming years. Higher bandwidth, real time interactive video, virtual reality, and improved web-based programming languages such as Java are among the capabilities that will become available for teaching and learning. With the fusion of video, voice and data transmissions, web access will be as common in homes of the future as television is today. While it is difficult to predict specific time frames for particular changes, it is certain that educators must learn to adapt to rapidly changing technological environments that promote learning in schools and in homes. Administrators must be ready to move forward, but not to invest in obsolete systems. Acquisitions of hardware and software must be coordinated with teacher preparation and curriculum applications. These challenges for the future can only be met if educators engage in active exploration today of the opportunities that have emerged so explosively since 1994.

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ИНТЕРНЕТ ПРИ ОБУЧЕНИЕТО В СРЕДНОТО УЧИЛИЩЕ

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През последните шест години в Института по технологии "Стивънс" се разработва и експериментира програма за прилагане на интернет в обучението по природни науки в средното училище. Програмата се спонсорира от правителствени фондове по линия на National Science Foundation и U.S. Department of Education и в нейните рамки са проведени курсове с над 5000 учители от Ню Джързи, Охайо, Аризона и Флорида.

Дейците на образованието търсят пътища, за да стане учебният процес по-въздействащ, да се увеличи мотивацията на учениците, да се осветлят по-добре трудните понятия и да се свържат учениците от класните стаи с огромните ресурси на външния свят. Нашият опит показва, че много от тези цели могат да бъдат постигнати с помощта на интернет с достатъчно компетентни учители при благоприятна училищна атмосфера. За да се постигнат добри резултати обаче, е необходимо да се извърши внимателно планиране и подготовка. Трябва да се намерят най-подходящите източници чрез интернет, да се направят необходимите връзки с учебното съдържание, да се стимулира когнитивното развитие на учениците, да се създадат възможности за изследователски дейности под ръководството на експерти и да се разработят подходящи учебни материали.