USING TELECOMMUNICATIONS TO IMPROVE SCIENCE TEACHING

Michael Robinson
Department of Curriculum and Instruction
University of Nevada
Reno, Nevada

Richard R. Powell
Department of Curriculum and Instruction
University of Nevada at Las Vegas

ABSTRACT

For nearly a decade a variety of federal reports, task forces, etc. have criticized U. S. science education and called for its' reform. An area that has been singled out for support from federal agencies concerns how math and science instruction can be made more effective. One area of science instruction of particular interest to large science and technology based federal agencies (i.e. the Department of Energy) is greater use of educational technology by the nations' schools; in particular low cost telecommunications. The value of telecommunications as a means for science students and teachers to access and share science information in the U. S. and other parts of the world is slowly being recognized and implemented in US schools. In the state of Nevada, the Office of Civilian Radioactive Waste Management has become actively involved in helping rural and urban schools to make use of electronic mail as an instructional strategy that holds the potential for improving science instruction and learning.

BACKGROUND

For over a decade, commissions, committees, and tasks forces, representing the needs of government and industry, have called for the improvement of science, technology, engineering and mathematics (STEM) education in the U.S. The federal government has set goals for improving the level of STEM education in the belief that the U.S. economic well being and standard of living can only be protected by maintaining world standards in science and technology. Federal money has been supplied to support two key areas. First, pre-service and in-service training for the teachers of science and mathematics. Second, the development of better curriculum and instruction to teach science and mathematics. The Department of Education, the National Science Foundation, the Department of Energy, and a number of other government agencies and private foundations are providing funding for projects that hold promise for improvements in the above two areas. In 1993, federal support will be substantial for projects that hold the potential to raise and maintain a higher level of STEM education in the U.S.

The evidence for the U.S. decline is based on the following:

1. Poor American performances in science and mathematics compared to foreign peers;
2. Insufficient preparation of many science and mathematics teachers;
3. Ineffective instructional techniques used by math and science teachers;
4. A declining number of students taking the upper division science and math courses and pursuing careers in STEM related fields;
5. Continued under representation of minorities, women and disabled persons in math and science; and
6. A low level of science literacy in the American public.

This paper will address item three, ineffective instructional techniques used by science teachers.

A major educational objective of the America 2000 (1) strategy is to establish national electronic networks that link all American schools with other sites where learning occurs (By the Year 2000, First in the World (2). Consequently, the Educational and Information Division of the Office of Civilian Radioactive Waste Management (OCRWM) of the U.S. Department of Energy, has targeted telecommunications as an important educational technology for disseminating science information to schools in the U.S. and in member countries of the International Alliance*. John Bartlett, the previous director of the OCRWM emphasized in his closing remarks in Engelberg, Switzerland (3), the need for education to be on the cutting edge of instructional technology just as the scientists and engineers who represent many fields of expertise are on the cutting edge of their fields in the site characterization at Yucca Mountain, Nevada.

RATIONALE

According to America 2000 (1), as a nation, "we are at best reluctant students in a world that rewards learning." Furthermore, there is still a public perception that anyone who has a baccalaureate degree in a discipline (e.g. biology, history, math, art) can teach it. However, recent research in teacher education suggests that becoming a teacher is cognitively a complex process that takes years to achieve expertise. Moreover, knowledge of how to teach your subject (pedagogical content knowledge) in a way that is understandable, interesting, and useful to students has become increasingly

* The International Alliance for Education in Radioactive Waste Management (IAERWM) was established to foster national science literacy in radioactive waste management through international collaboration in education. The members of the IAERWM are Austria, Belgium, Canada, Finland, France, Germany, Japan, The Netherlands, Spain, Sweden, Switzerland, The United Kingdom, and the United States.

important in the light of social problems and heterogeneous classrooms. By the year 2000, one American in four will be poor; one in three will be a minority group member; and one child in 12 will lack the English language proficiency required for learning."(4) In addition, through their work in local science classrooms, the authors have found that for many high school students, the school academic program may be third or less in priority after sports, a job, peers, and family problems as the number of dysfunctional families continues to increase.

When students are motivated to learn, traditional teacher directed instruction (e.g. lecture with or without props) may be effective. Teacher directed instruction may also be faster, cheaper and easier to plan because it requires few support materials. Also, when the teacher is directly in control of instruction it is generally easier to manage the classroom. In spite of the advantages, exemplary science teachers are relying less and less on lecture as an effective instructional strategy. According to Yager, (5) exemplary science teachers provide students with direct experiences in and out of the classroom. Traditionally, direct experiences in science have involved student lab work, projects, field trips and more recently micro computer based laboratory (MBLs) exercises. The use of MBLs fits closely with how today's students prefer to learn. In the age of home computers, MTV, nintendo, laserdisc movies, and CD players, educators have the opportunity to use the technologies of our society in school instruction. It is apparent how many hours even our best students spend in front of a screen in their leisure time. Contemporary students may choose not to learn because they are bored with the instructional strategy even when the information is interesting and relevant. When students arrive in the classroom the teacher has little or no control over the education ethic they receive from the home, the interference of their jobs, or the prior experience they have had in the subject. Therefore, what the teacher can do is motivate them by using today's technologies to provide more interesting, innovative instructional strategies. Instructional strategies that are in tune with vision, sound and interactivity of modern industry and entertainment may be useful for motivating today's students to learn (6).

The remainder of this paper will be devoted to the use of telecommunications as an effective, motivating instructional strategy for improving science teaching in American schools. It will address the following questions: 1). How is telecommunications currently being used in education; 2) Why is telecommunications not being used more; and 3). How is telecommunications being used in science education in Nevada?

HOW IS TELECOMMUNICATIONS CURRENTLY BEING USED IN EDUCATION?

The information age that modern industrial societies have *now entered* is based on computers and the networks that connect them. There are literally hundreds of millions of computers in the world from super computers that manipulate billions of commands to home video games controlled by a few commands. Computers are opening new realms in science, education, and entertainment through complex simulations that are closer and closer to reality (virtual reality). Business mail can now be received in five seconds and stock marked transactions can take place in a few minutes. It is already suspected that computers will widen the gap between the rich and poor and the educated and non educated (7). One way to help fulfill the educational priorities of the U.S. is to make sure that all students have the opportunity to access and share information whether they are in wealthy cosmopolitan urban centers or in isolated rural schools. Making data bases available to all schools would be one way of providing this opportunity.

Telecommunications can take many forms depending on the needs and money of the institution. In U.S. higher education the primary needs are in a) accessing and sharing information by and between faculty, and b) in sending courses to remote areas (distance learning) that are expensive or inconvenient for faculty travel. Electronic mail (e-mail) is used by academics to communicate with colleagues in other parts of the world with internet and bitnet being the most popular networks. Courses are carried to rural areas through conventional copper wire, fiber optics, and wireless satellite receiver downlinks. For example, the Agricultural Satellite Corporation (AgSAT) offers 34 land grant institutions academic instruction, cooperative extension programming, and agricultural research information. Fiber optics offers the greatest potential for the two directional interaction of full motion video but it is also the most expensive and least available. Moreover, some colleges of education are beginning to demonstrate the instructional applications of telecommunications in pre-service teaching methods classes.

In K-12 schools, telecommunications still has limited use. Most systems are what the U.S. Office of Technology Assessment (OTA) (8) would call hybrids and involve one or more of the following: Satellite, instructional television, microwave, cable, fiber optics, and computers. New developments are emerging in computer, telecommunications, and video technologies that are expanding the choices. Some rural schools have satellite receivers to teach foreign languages and upper division science and math courses. Two of the better known programs are SERC and KidsNet. The Satellite Educational Resource Consortium (SERC) provides courses that would otherwise not be available to high school students. In the SERC program, the telephone and computer enable students to interact with their teachers. A number of elementary schools use the National Geographic Kids Network (KidsNet) to share scientific research on real-world issues such as acid rain, water pollution and solar energy.

WHY IS TELECOMMUNICATIONS NOT BEING USED MORE?

The use of distance learning in U. S. Department of Defense Schools indicates that distance learning can be as effective as face-to-face instruction in the classroom (9). Since it has been used primarily with adult learners in industry and military training, and continuing education in higher education, good research to evaluate its effectiveness is mainly in these areas. Even though the learning effectiveness is high in these cited areas, the evidence is incomplete in K-12 education (8). Until telecommunications becomes more widespread in K-12 education it will be difficult to fully assess its student learning effectiveness.

In addition to the unanswered question about its effectiveness in promoting learning in K-12 students, there are other reasons why distance learning is not be used more in K-12 education. Three of them will be briefly dealt with in this paper. First, administrators and teachers often think the cost is too high. Little do they know that almost any *computer can* become an e-mail terminal when a modem is available and

attached to a dedicated phone line. Still, a rural school that has to pay for a network and long distance calls may find the price too high. To reduce operating costs, phone companies are often supportive of giving a reduced long distance rate to schools. In addition, some universities are allowing access to one or more of their networks without charging teachers a user fee.

From the authors experiences in working with science teachers, a second reason that telecommunications are not used more is lack of teacher awareness. Older teachers often do not know the potential for improving instruction through the use of e-mail. Even when they are informed they may need some in-service training to overcome the barrier and intimidation of what they perceive as a complicated technology. They may need release time and financial support to travel to a university or other institution to receive the training. The nature of the technology makes it hard to hold classes for more than a few individuals in a field setting. After procuring the needed hardware and software and receiving support for training, administrators still need to evaluate teachers in their effectiveness in using the technology. This means that administrators must also be aware of the value of the technology for improving instruction.

A third reason why the technology is not being used more is the lack of awareness of college professors of the instructional benefits of the technology. If they do not promote its value and require pre-service teachers to learn how to use it in their teaching methods classes it is certainly less likely that the technology will soon become widespread in the schools. Therefore, college instructors also need support for a). procuring the required hardware and software and b). receiving the release time to learn how to use it.

TELECOMMUNICATIONS IN SCIENCE EDUCATION IN NEVADA

Science educators are generally provided more opportunity to use telecommunications than other K-12 teachers. Because science and math are nationally recognized as critical areas more materials and financial support are available to improve teacher education in math and science than in other subjects. Partly as a result of this increased support, there are a number of science and math networks that have been set up by states, universities and/or school districts throughout the U.S. and other parts of the world. The Educational Telecommunications Network (ETN) in Los Angeles, California is a large network in the proximity of Nevada. ETN is a U.S. Department of Education sponsored program that includes interactive elementary science by satellite. ETN offers Telecommunications Education for Advances in Mathematics and Science (TEAMS). In the future, Las Vegas may be able to use ETN's elementary math and science network.

Historically, Nevada has lacked financial support at the state and district levels to begin a project like TEAMS. However, government officials are now recognizing the potential of educational technology for improving instruction. Consequently, the state budget for school years 93-95 proposes that millions of dollars be spent on making educational technology a part of every classroom, including telecommunications. In the meantime, two small state networks have started (i.e., Geographic Alliance and Bristlecone) for the purpose of enhancing geography and language and writing skills, principally at the elementary level. On the international level, Computer Pals Across the World (CPAW) is an electronic mail writing project that provides students with the opportunity for cultural exchange through reading, writing, and information surveys that help shape global perspectives. It connects classrooms in 15 countries including the UK, Japan, Norway, Germany and Canada.

The fastest growing telecommunications project in Nevada is through the Nevada Science Project (NSP). It was sponsored by the Department of Energy's Education and Information Division of the OCRWM. It will help to fulfill the goal of the America 2000 strategy to establish national electronic networks that link all American schools with other sites where learning occurs. To this end, one mission of the DOE is to supply and share current information in science and technology in a timely manner as a supplement to standard curricula (2). To help carry out this mission, government agencies have begun donating extra equipment to schools as part of the government's effort to promote better instruction in math and science education.

In the Spring of 1992, through the generous efforts of the OCRWM, over 300 pieces of computer equipment, including 50 Macintosh computers, were donated to the NSP, with the objective of establishing a middle school (MS) e-mail science network. To further that objective, two telecommunications workshops were held in the Summer of 1992 to train middle school science teachers on how to use e-mail to access internet at the University of Nevada in Reno and Las Vegas. Teachers also learned how to access and use other networks such as gopher and usenet.

A total of 33 teachers took part in the two telecommunications workshops. The universities furnished free user numbers for internet, and the DOE provided a budget to buy the modems and software for using e-mail. Each principal of the participating schools agreed to furnish a dedicated phone line for e-mail in the science room. Cables and other peripherals as well as some money to repair and/or replace equipment was also part of the project. Contact with the teachers has been maintained through e-mail. Further updates and reinforcement on how to more effectively use e-mail and to troubleshoot any hardware problems is continuing. Currently, the program is seeking a reduced rate from the phone company for long distance calls made from rural schools to the two university internet numbers. File servers, to be installed in three locations in the state, may soon solve this problem. Furthermore, some teachers are already using the OCRWM education network, INFOLINK, to learn more about OCRWM program information and products. As more science networks become available through science based government agencies such as DOE, information about the networks will be relayed to the schools using e-mail. Newton, out of Argonne National Laboratory, is the most recent network Nevada science teachers are beginning to use. Services for teachers who use Newton include ideas for classroom demonstrations, activities, and field trips; on-line conferences with scientists; calendars of conferences, lectures, symposia, workshops and other professional events for science teachers.

CONCLUSION

It is obvious that because of their extensive resources, key science based agencies in the U.S. Federal Government can play a major role in improving science and math education in the U.S. As these agencies, (e.g., the Department of Energy) make some of their resources available, in addition to improving science and math instruction, they can help promote

science literacy in the general school population and motivate more students to pursue careers in science and its related fields. Telecommunications is a teaching and learning strategy that offers the prospect for improving science teaching as well as making upper division science courses available to schools in remote areas and motivating more students in the upper grades to continue taking science. The international involvement of DOE in nuclear education provides additional connections to help establish telecommunications as an international learning strategy. Furthermore, the prospect of improving bicultural understanding between the U.S. and other countries is inherent in this learning strategy.

In the near future, it is hoped that the middle school science teachers in Nevada will be able to establish links with schools in Canada, the UK, and other International Alliance countries. At first, Computer Pals Across the World might be a reasonable place to begin this international communication since the member schools already use e-mail. After schools are identified in the International Alliance, the nuclear waste resources being identified by the member countries can be shared and discussed by students using e-mail. Such telecommunications exchanges can promote science teaching as a body of content, a way of thinking, and a way of investigating science in other parts of the world. International sharing of information on global science issues through joint school projects is a feasible way to practice the science skills and processes that should be learned and transferred to everyday life while also promoting bicultural understanding.

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