1998

Integration of Technology into Science Education

Paul Zahner
University of Northern Iowa

Integration of Technology into Science Education

Abstract
In this paper, the importance of integrating technology into science education is discussed. The correlation between technology and science is noted and national science standards are examined. The evolution of today's learners requires a change in science education, and technology can serve as a vehicle for meaningful reform. The starting point for any change in science education lies with the teacher, who must adopt new strategies to meet the needs of all types of learners. Various examples of these teaching plans are discussed within this paper. Other important components of the change process include school administration support, especially financial. These considerations are discussed as they relate to planning for reform. Several examples of technologies available to science educators are discussed, including computer laboratory interfacing systems and simulations. Computer research and presentation tools, namely computer Internet access and multimedia software, are other technologies widely used by science educators. Distance education and its potential impact are discussed, noting advantages and disadvantages of these systems. Other technologies, from drill and practice software to videodisc players, are examined. Concern for special students, e.g. learning disabled, must be discussed before any technology is adopted and integrated. Care should also be taken to meet the national standards for technology and science. These are the important components of any plan for integrating technology into the science classroom.

INTEGRATION OF TECHNOLOGY INTO SCIENCE EDUCATION

A Graduate Research Paper

Submitted to the

Division of Educational Technology

Department of Curriculum and Instruction

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

UNIVERSITY OF NORTHERN IOWA

By

Paul Zahner

June 13, 1998

This Research Paper by: Paul Zahner

Titled: Integration of Technology into Science Education

has been approved as meeting the research requirement for the

Degree of Master of Arts

Sharon E. Smaldino

July 2, 1998

Date Approved

Graduate Faculty Reader

Robert R. Hardman

July 2, 1998

Date Approved

Graduate Faculty Reader

R. Muffoletto

7-17-98

Date Approved

Head, Department of Curriculum
and Instruction

In this paper, the importance of integrating technology into science education is discussed. The correlation between technology and science is noted and national science standards are examined. The evolution of today's learners requires a change in science education, and technology can serve as a vehicle for meaningful reform. The starting point for any change in science education lies with the teacher, who must adopt new strategies to meet the needs of all types of learners. Various examples of these teaching plans are discussed within this paper. Other important components of the change process include school administration support, especially financial. These considerations are discussed as they relate to planning for reform. Several examples of technologies available to science educators are discussed, including computer laboratory interfacing systems and simulations. Computer research and presentation tools, namely computer Internet access and multimedia software, are other technologies widely used by science educators. Distance education and its potential impact are discussed, noting advantages and disadvantages of these systems. Other technologies, from drill and practice software to videodisc players, are examined. Concern for special students, e.g. learning disabled, must be discussed before any technology is adopted and integrated. Care should also be taken to meet the national standards for technology and science. These are the important components of any plan for integrating technology into the science classroom.

TABLE OF CONTENTS

CHAPTER ONE

Introduction

Education is in a constant state of metamorphosis. Basic understanding of reading and writing has given way to the stand-alone disciplines of social studies, English, math, and science. Even the fine lines between these curricular areas have been erased with the push for interdisciplinary learning. With the advent of technology, a discipline that seems to be more difficult for educators to define than for students to learn, the cross-curricular approach has become even more widespread. Technology has been integrated into every academic area in all grade levels. The level of this integration depends on the teacher, the particular discipline, the type of school, and the school's ability to provide these technological tools of learning. Technology, nonetheless, has changed the way we educate our nation's youth.

The discipline that seems to lend itself to a cross-curricular approach with technology is science. Throughout history, scientific discovery has been achieved in great part due to the development of new technologies (National Science Education Standards, 1996). Technological problems create the demand for new scientific knowledge. New technologies extend the research of the nation's scientists (Project 2061, 1993). Whatever the connection, today's learners must develop skills in the area of technology design and develop an understanding about the relationships between science and technology.

Besides this obvious correlation between science and technology, there are many more reasons why technology should play an important role in any science classroom. In the past, science classrooms have been teacher-centered, with the instructor being the supplier of factual information and the student being the listener, the note-taker. Memorization of facts in tremendous quantity and assessment using long, multiple choice examinations was the status quo (Dwyer, 1994). Science classrooms are now required to be learner-centered. The teacher and pupil now collaborate on projects and investigations. The emphasis is no longer on rote learning but on the understanding of scientific processes and concepts. Portfolios and performance standards have replaced standardized tests as the preferred method of assessment (Dwyer, 1994). Technology is a tremendous help in changing the science classroom.

In the past, typical technology in the science classroom included various types of lab equipment, overhead and film projectors, and the chalkboard. A computer may have been added to this list in some schools, but it was mainly for the teacher to use or for word processing (Rhoton & Sternheim, 1993). Different technologies are a driving force behind science classroom reform. Lab computer interfaces, simulations, videodiscs, interactive television, calculator-based labs, multimedia, and a vast array of computer software are tools the science teacher can use to transform the science classroom into an interactive, learner-driven world of discovery. Students can become scientists with a desire to understanding the natural world.

The evolution of today's youth is another reason for science classroom reform. Students enrolled in a typical science class are becoming more and more diverse. A science teacher must vary instruction to meet the needs of visually and auditory challenged learners, and students with learning disabilities (Kucera, 1993). Instruction must be delivered differently, evaluation must be altered, and labs have to be changed for safety reasons. Computers and other educational technologies are a way to effectively reach these students.

Transformation of the science classroom can occur in various ways. As with any technology adoption, careful planning using instructional development methods is required for success. Innovative teachers must have a vision and a desire to change to way they teach and the way students learn. If the science classroom doesn't change, students may look elsewhere for job opportunities. Those students who do pick a science career may find themselves unprepared for our technological society.

To properly change the science classroom to meet the needs of society, an examination of the present state of science education and examples of innovative integration of technology are needed. All across the country, science educators have developed new and interesting uses for technology. These examples should provide a template for changing the typical science classroom.

Research Question

The research question for this paper is as follows: How can available technologies be properly selected and integrated into science education? A review of available literature and discussion with educational professionals was done to answer this question. An explanation of the methods used to identify and locate sources of information is included.

Terms

computer – a machine that processes information, usually in the form of numerical data, according to a set of instructions (Newby, Stepich, Lehman, & Russell, 1996).

cooperative learning – an instructional approach that involves small heterogeneous groups of students working towards a common academic goal or task (Newby, Stepich, Lehman, & Russell, 1996).

discovery – an instructional approach that uses and inductive, or inquiry, method to encourage students to find "answers" for themselves through the use of trial-and-error problem solving strategies (Newby, Stepich, Lehman, & Russell, 1996).

distance education – an educational process in which a significant proportion of the teaching is conducted by someone removed in space and/or time from the learner (Perrton cited in Hanson, Maushak, Schlosser, Anderson, Sorenson, and Simonson, 1996).

drill and practice – a series of practice exercises design to increase fluency in a new skill or to refresh an existing one (Newby, Stepich, Lehman, & Russell, 1996).

fiber optics – a glass filament, thinner than a human hair, through which are transmitted digital light impulses. Voice and video signals are converted into light impulses at one site, sent along the fiberoptic filament at the speed of light and converted back to video and voice signals at the other site (Elliot, 1995).

hypermedia – Extends the notion of hypertext to other media besides text. In a hypermedia system, nodes of information may contain graphics, animation, video, and audio, as well as text (Newby, Stepich, Lehman, & Russell, 1996).

interface – An electronic go-between by which the computer communicates with a peripheral device (Newby, Stepich, Lehman, & Russell, 1996).

internet – a network of databases offering electronic access to many forms of information, including document browsers, general communications systems, electronic mail, newsgroups, and hypertext retrieval systems (Pool, Blanchard, & Hale, 1995).

Iowa Communications Network (ICN) – a fiberoptic network designed to deliver distance education to the citizens of Iowa. When completed, no Iowa resident shall be more than twenty miles from the network (Elliot, 1995).

multimedia – a collection of media used to collect video, audio, and graphics. Computers are then used to digitize this information to make projects and presentations (Shapiro, Roskos, & Cartwright, 1995).

scanner – Uses technology similar to a photocopying machine to take an image from a printed page and convert it into a form the computer can manipulate (Newby, Stepich, Lehman, & Russell, 1996).

simulation – An instructional approach involving a scaled-down approximation of a real-life situation that allows realistic practice without the expense or risks otherwise involved (Newby, Stepich, Lehman, & Russell, 1996).

smart lectern – lectern with computer, overhead camera, VCR, and a system to control electronic projection equipment. Also available are environmental controls, such as lights, shades, audio level, etc. (Shapiro, Roskos, & Cartwright, 1995).

software – The programs or instructions that tell the computer what to do (Newby, Stepich, Lehman, & Russell, 1996).

technology-enhanced learning environments (TELE) – an attempt to stimulate classroom activity by demonstrating or using specific software, by promoting high levels of interaction, and by involving students in simulations or data-collecting investigations (Shapiro, Roskos, & Cartwright, 1995).

tutorial – An instructional approach in which a tutor presents the content, poses a question or problem, requests learner response, analyzes the response, supplies appropriate feedback, and provides practice until the learner demonstrates a predetermined level of competency (Newby, Stepich, Lehman, & Russell, 1996).

videodisc – A video storage medium composed of recorded images and sound similar to the CD (Newby, Stepich, Lehman, & Russell, 1996).

CHAPTER TWO

Methodology

Sources for this research paper were chosen in the following way. Articles were identified as being related to science, integration, and technology by doing keyword searches of the ERIC (Educational Resources Information Center) database over Internet connection. Actual articles were then located in the Rod Library on the University of Northern Iowa (UNI) campus in Cedar Falls, Iowa. Other sources were identified as being related to science and technology integration by their use in other reports done for the Master's in Educational Technology degree at UNI. The articles were located by searching through educational journals, discussion with educational professionals, and ERIC searches done by staff consultants at Area Education Agency (AEA) 12 in Sioux City, Iowa.

The sources were chosen for inclusion based on several criteria. The articles were included if they fit the topic of science and technology, if they related to specific examples of technology use in science education, if they discussed the needs of special students, and if curricular integration was discussed. The articles were then evaluated for content, reference, and compatibility. This evaluation included an initial scan for content, a critical reading the articles, and an extraction of the valuable information. This is the methodology by which the sources were located and identified.

CHAPTER THREE

Review of Literature

Teacher Adaptation

Changing the physical environment of the science classroom is not limited to the introduction of new technologies. A far more important aspect of this metamorphosis of a typical classroom involves the science teacher. Before any new equipment, computers, or multimedia are purchased, the teacher must completely change the way instruction is delivered. This educator must also change the way teachers view learners (Greenbowe & Burke, 1995). For students, what is the best method for acquiring the knowledge and skills important in science? Amend, Furstenau, Howald, Ivey and Tucker (1990) conclude that students learn best by what they experience. Exploratory situations in which the student is embedded in the scientific discovery result in greater gains in the understanding of science. Many partake in the constructivist view of learning, where the learner actively constructs the knowledge they have, rather than being passive receivers of information (Richards, Barowy, & Levin, 1992).

Teachers must realize that students are used to the traditional method of science instruction. Most students would rather be spoon-fed information in their science courses (Matray & Proulx, 1995). This is not true learning. Science is a discipline that attempts to explain the world around us. Young learners have explanations of these phenomena already established in their minds. Many of these hypotheses are warped or completely incorrect. Teachers must engage students to rebuild their explanations in their minds, by reflecting and modifying their view of how the world works (Richards, Barowy, & Levin, 1992). This can not be accomplished by simply stating the correct scientific information in lecture format. Changing their views is improbable if verification labs, where the outcome is assured and discovery is minimized, are the only ones done.

One option is for the classroom to be changed to a discovery laboratory with appropriate interactive lessons. This physical environment should also be a resource center that is learner-driven, directed by the teacher, now a facilitator of learning. Innovation by the teacher is the key, resulting in more student-teacher interactions in the course of discovery. The teacher becomes, in a way, an "idea coach" (Kumar & Wilson, 1997). This involves creating cognitive conflicts with scientific information, assigning cooperative learning opportunities for discovery, and guiding the conduction of experiments designed to allow the students to have the opportunity to obtain meaningful results (Richards, Barowy, & Levin, 1992).

The discovery laboratory is just one possibility available to the innovative science teacher. From the experience of teaching, this author believes it to be the best choice. For many educators, the need for evolution is not apparent. In order to change they way science instruction is delivered, there has to be some strong force driving the change. Integration of new technologies is the driving force behind this renaissance in science, and the result is teacher adaptation.

Considerations

Once the commitment to change has been made by the science teacher, an in-depth study of the available technologies can be made. Careful attention should be given to the people who will use the technology, the physical location where the technology will be placed, and which technologies will be appropriate for these learners and this classroom (Shapiro, Roskos, & Cartwright, 1995). Visits should be made with faculty and consultants at other institutions. Television and computer experts should be contacted for their input (Shapiro, Roskos, & Cartwright, 1995). This study should result in a science technology plan that is needs-based, data-driven. Following this approach will hopefully earn science educators the backing of faculty, administration, and school board. Once the plan has been approved, change can become a reality.

The technology choices available to science departments are vast. With an unlimited budget, the laboratory may resemble government research or university facilities. Unfortunately, monetary restrictions will be a formidable obstacle. True change requires a commitment of money from school, community, state, and even private and federal grants. Donations from local business and industry of older, used equipment is also possible. For example, the Sergeant Bluff-Luton Community School District in Sergeant Bluff, Iowa has a strong business partner in the telecommunications firm MCI. During a recent update of MCI's computer system, one hundred IBM 486 computers were deemed expendable. A decision was made to give these computers to the school district as a gift to education, and as a tax deduction. The science department was fortunate enough to receive thirty of these machines. Although this is not necessarily a possibility for all school systems, a gift of used computers from business is an option.

Funding problems should not, however, interrupt the process of change. New technologies can be added when funding is available. The focus of this discussion is not necessarily financially feasible for most schools, at least short-term. Over a span of several years, the following technologies can be integrated into a science classroom.

Available Technologies

Computer lab interfaces. Due to the importance of the creation of a discovery-type atmosphere, change in experimentation procedures is a logical first step in the change of the typical science classroom. One possible advancement is to implement computer technology, which can improve the quality of learning, increase cost-effectiveness, and optimize the use of time in the science laboratory (Amend, Furstenau, Howald, Ivey, and Tucker, 1990). In order to utilize these computers, many science classrooms are going to computer-based data-collecting equipment. Using computers installed directly in the laboratory, many different inquiry lab experiences can be done by the students.

Once the computers have been installed, there are two other major components of the data collection system. In order to gather data, probes and sensors must be purchased and integrated. Various probes are available with the computer-based laboratory. Probes for detecting motion, pH, relative humidity, heart rate, light, and temperature are available from various vendors. With a large variety of probes, the instrumentation necessary for every type of data collection in chemistry and physics classes is possible (Amend, Furstenau, Howald, Ivey, and Tucker, 1990). The other vital component of the system is the interface, which allows the information from the probes and sensors to go to the computer (DeWeerdt, 1996). Two types of interfaces are the serial box interface and the universal lab interface.

Experiments become interactions among the components of the data collection system. The experiment is performed and data collected by some sort of detector, a probe or sensor designed to gather the appropriate information. The data is sent from the detector to the interface, which also sends electronic signals back to control the probe. The interface sends the information to the computer, the central component in the system. Within the processor of the computer, mathematical calculations and manipulations are performed. A graphical representation of the data is presented via the monitor to the student. The student controls the data by making adjustments to the graphs and changing the parameters of the data collected (Amend, Furstenau, Howald, Ivey, and Tucker, 1990). This type of data collection is the future of laboratory science in the high school classroom.

Use of this type of experimentation has been well-documented in renowned scientific journals. There are many examples of computer-integrated data collection. Physics examples include the use of force sensors to measure centripetal force in an experiment described by Charles Henderson (1998) and utilization of graphical analysis on data taken from 100-meter dash sprinters was described by Wagner (1998). Biology teachers can reference an experiment on milkweed seed dispersal that uses wind speed and distance values collected by detectors and manipulated with graphical analysis (Bisbee & Kaiser, 1997). Chemistry is impacted by the use of computers and probes in an experiment on phase changes. In this experiment, students monitor the temperature of a beaker of vegetable shortening as it cools. At the same time, they monitor the light transmission through the solution, looking for rapid changes in data values (Hart, 1998). These examples can provide a basis for changing existing lab experiences and create a template for the production of new discovery laboratories.

Powers (1989) describes variety of activities wrapped into the computer-based laboratory. The probes and sensors allow students collect, store, display, and print data and do rapid statistical calculations. Learners can also create their own experimentation and analyze the data they collect. This helps to achieve the goal of an inquiry, learner-driven approach to science education (Rhoton & Sternheim, 1993).

The advantages of computer-based laboratories are apparent. Students can collect all the data needed. They make precise measurements, allowing them to achieve research-like accuracy in their experimentation. The interface, probes, and computer software are very easy to use. Finally, these systems are expandable at a relatively low cost to the school district (Amend, Furstenau, Howald, Ivey, and Tucker, 1990).

Simulations. Simulations are computer programs that use functional and effective models to teach science. These representations of real scientific events and phenomena help to relate scientific theory to laboratory experimentation. They describe the action of a particular system over time. When used with hands-on activities, simulations can address the basic understanding of how the universe works (Richards, Barowy, & Levin, 1992). Simulations provide a set of experiences that challenge students to reconstruct their own explanations of scientific events.

One area of science that has been impacted by simulations is biology. Friedler, Merin, & Tamir (1992) developed a computerized simulation that could be integrated into the cell biology curriculum. This simulation was tested against traditional laboratory practices. The findings indicated that although it is possible to teach new concepts with simulations, it places a heavy strain on the student because the material and the simulation must be learned. Much time was spent in instructing the student as to how to use the computer. This created a high level of anxiety in some learners. Advantages were seen, though, because those at different levels of understanding could proceed through the simulation at their own pace. Learning a difficult concept like cell biology is challenging; a simulation provides another source of information for the learner. Simulations have been shown to significantly compliment a biology curriculum (Matray & Proulx, 1995).

Simulations are a viable alternative in several situations. Many scientific phenomena are unobservable, due to their size or distance. An example might be atomic structure, too small for any device to actually monitor. The situation may be uncontrollable and dangerous, as in a nuclear bomb explosion, or not be economically feasible, like cold fusion (Richards, Barowy, & Levin, 1992). A simulation may be valuable when processes occur very slowly, as in evolution of species; or very fast, as in the speed of light. A simulation may be valuable in describing these situations.

Teachers who have used simulations have some concerns regarding their use. The first concern is that simulations are not real phenomena; the learner begins to believe that the actual event or process is exactly as they see on their computer monitor. Simulations are based on perfect conditions, and rarely accurately predict the outcomes for different scenarios. Secondly, the simulation is only as good as the model it is based on. Nothing in science is absolutely true; all hypotheses, theories, and laws are subject to change. Finally, simulations can misrepresent or oversimplify actual events, or miss some situations entirely. These are the concerns represented by Richards, Barowy, & Levin (1992).

Simulations are best utilized in the following manner. Teaching a concept, like the mechanics of a bouncing ball, should involve a simulation and actual lab experiences. This is not possible for all topics covered by simulation, but is a guideline for educators to follow. Using more than one method could reach more learners, and shows young people the discrepancies between simulations and real life.

Research tools. A large part of any scientific endeavor is research. The Internet, available to computers in the science laboratory if networked, would give students instant access of various databases worldwide. These databases contain a tremendous amount of information on many topics in science. Individual or group research projects can be done from the science laboratory, eliminating the need for excursions to the media center (Greenbowe & Burke, 1995).

The question for science students doing research is in their method of delivery of the information they have gathered. A type of research project is one that ties Internet research to some sort of multimedia. The hypermedia research project, or paperless research project, would be possible in this science configuration. Students would spend several days doing research, then create a storyboard and work with some hypermedia software, such as Linkway Live

(Brown, Coleman, & Fischback, 1996) or Hyperstudio. These programs could be loaded on the computers already in the science classroom.

Due to its nearly limitless potential, multimedia production is potentially too vast an undertaking for the computers in the science laboratory. If these computers in the laboratory are lacking in the memory or speed needed to run and produce multimedia, a comprehensive multimedia workstation could be developed for use by the entire system. One possibility involves team multimedia workstations using videodisc players, television monitors, and a multimedia production computer can be invaluable to students who must create presentations to report laboratory findings (Sundseri, McClure, Kilburg, & Hettinger, 1996). Placed in the school's media center, this workstation may be configured using a teamwork pod, consisting of a triangle eight feet on each side, with networked monitor, videodisc, etc. (Shapiro, Roskos, & Cartwright, 1995). Multimedia would allow students to also go into digitized video, audio and graphics, making the quality of their projects and presentations very high (Shapiro, Roskos, & Cartwright, 1995).

Multimedia supports teaching in many ways. In addition to learner-based research, collaborative teaching and whole class instruction are other ways multimedia can support learning in the science classroom. Authentic assessment and portfolios are good places to use multimedia, being either teacher-produced or student-driven. In the end, group projects and cooperative learning activities may be the most beneficial use of multimedia. Multimedia will increase the ability to produce life-long learners who are successful beyond what the normal classroom could produce. The main reason for this is that working in teams on multimedia and doing cooperative tasks are a main part of the world of work (Sundseri, McClure, Kilburg, & Hettinger, 1996). Schools are also supposed to prepare kids for a technological world. Teaching more application of computer use, like multimedia, rather than keyboarding and programming is of benefit to our clients, the learners (Matray & Proulx, 1995).

Distance education technologies. School systems devoted to changing science instruction have another alternative in distance education. Most schools have or will have some access to distance learning technologies, such as fiber optic video and audio feeds or satellite delivery. A science department interested in change should take advantage of this rapidly developing field.

The concept of distance education and its possible effect on the area of science are very important topics. A strong movement has begun in the state of Iowa to reform science education using the Iowa Communications Network, a fiber optic delivery system known as the ICN. Reforming the entire curriculum, the learning processes, and the ways we engage students are being examined in the state. A group called the Iowa Distance Education Alliance is working with the Iowa Chautauqua Program to use distance education to change science instruction (Yager, 1995). Before looking at several examples of reformed science curricula using interactive television and distance learning, a discussion of general distance education is necessary.

Distance education, generally, and interactive television, specifically, have many benefits over traditional instruction. Whether these things can be related to science remains to be seen. First, they can extend and improve an institution's educational opportunities (Walsh & Reese, 1995). Many schools can not offer courses due to low student enrollment and geographical isolation. Teacher shortages can severely limit the comprehensiveness of a high school curriculum, especially in the area of science (Martin & Rainey, 1993). As the world changes and rural communities become less attractive to teaching professionals, distance education may be a viable alternative to traditional classroom instruction.

Related to teacher shortages is the tremendous cost associated with instruction. Schools routinely pay teachers the majority of their annual operating budgets. Many rural districts can't afford to hire teachers for every course offering. Interactive television and distance learning may be a viable alternative. Even though the start-up cost is high, the purchase of interactive television equipment will pay for itself many times over in a short period of time. This reduction of cost would be the second benefit of distance education (Walsh & Reese, 1995).

Another advantage of distance education and interactive television is the decreased amount of travel time (Greenbowe & Burke, 1995). Long distance courses and discussion sessions allow districts that are isolated to come together. Such things as electronic field trips and famous speakers using a system like the ICN drastically decrease the amount of travel time associated with these special events. Again, in the long run, cost would be diminished using distance education.

Other advantages students gain using distance education and interactive television include increasing student responsibility, diversifying their education, and meeting new people. Instructors using this system tend to be excellent teachers who help students remain interested and keep them on their toes. Experiments tend to be designed better and more teaching styles are used. All of these things help students who take distance education courses to be successful (Martin & Rainey, 1993).

There are, however, disadvantages to using distance education. It is not for all learners. There is no direct contact that can promote discipline problems. Average to below average students who need the personal attention is definitely a problem. Making up missed assignments becomes very problematic (Martin & Rainey, 1993). In addition to classroom difficulties, school management has its own problems to deal with. Who pays the access charges? Who administers the tests in satellite locations? Who pays the teachers to develop the course and how can they afford to pay teachers for the extra time needed to prepare daily for such courses (Mirabito, 1996)? These are considerations that often dampen efforts to develop and teach using this technology.

Distance education has its advantages and disadvantages. These become magnified when relating this technology to science instruction. Science has inherent qualities that increase the challenge of teaching with interactive television. The preparation time required for each class is incredible. Laboratory work and research, the framework of modern science, is severely disrupted. Despite these problems, many teachers have attempted to create effective instruction using distance education and interactive television.

Many scientific examples can be found where a special activity, such as a speaker, is delivered over great distances using distance education. In Mt. Ayr, Iowa, a famous scientist from the University of Iowa, Dr. Van Allen, talked to students about his theories for ninety minutes. This was the only time this activity was delivered and these students will treasure it forever (Elliot, 1995).

The Interactive Mars Base Project is another distance education activity where students build bases to be placed on the planet Mars and then share their finished products with others over the ICN. Also, and interactive satellite teleconference among the participating schools and the National Aeronautic and Space Administration (NASA) allowed the students to discuss their projects with NASA engineers. Commitments from scientific organizations like NASA should continue to increase, broadening the activities available to the distance learner (Christensen, 1996).

In addition to special speakers and projects, complete classes have been taught over distance education with interactive television. A school with access to the ICN or satellite transmission could provide new choices for science students. An interesting effort was the development of an electronic lab-based course offered by North Iowa Community College in Mason City, Iowa and delivered via the ICN. Using programs such as Electronic Workbench, students studied electronics, circuits, and other topics over the fiber optic network. In its first trial, sixty-six students all over north Iowa received this course. The results and attitudes of the students were excellent (Byman, 1996).

When developing instruction for interactive television, several considerations need to be made. The instructor needs to cogitate the lab component of a typical science course. Home-based laboratories, demonstration labs, and computer simulations (Greenbowe & Burke, 1995) are possible alternatives that should be carefully studied. Care should be taken to limit class size and maximize student-on-task behavior. Because this medium has many potential technical problems, back-up plans are required (Boone, 1996). One should look into ice breakers, different teaching styles, and alternative questioning techniques. Finally, balancing the preparation time with the activities requires a tremendous amount of organization. A teacher needs to evaluate every component of teaching and learning and make any alterations to benefit the distance learner (Elliot, 1995). Only then will the learner be successful.

Distance education is a medium with incredible potential. This type of technology is being integrated into the science curriculum. When carefully planned, the benefits of distance education far outweigh the pitfalls.

Other technologies. Many other technologies are available for integration into science education. One important tool that can be incorporated into a science classroom is the smart lectern. The teacher's podium in the system has a networked computer, overhead or other projection capability, and control of lights, shades, etc. An electronic presentation system, like Microsoft Powerpoint, that can connect the computer to a television monitor or projection system, is the next step in improved delivery of instruction. Lecture is still a valuable tool in the delivery of information, a tool that can be improved with technology. A large room might require a student response system and an unobstructed view of the podium. These components represent a simple technology-enhanced learning environment, or TELE (Shapiro, Roskos, & Cartwright, 1995). This system does not meet the goal of a more interactive learner-centered environment, but may serve as a starting point for the development of technology-based science delivery system.

The computers placed in the science laboratory have many other scientific uses. Data secured from laboratories needs to be reported. Most reporting is done in written form. Lab reports are a staple of college lab-based courses, and should be implemented as a strategy in the high school science room as well. Word processing, spreadsheet, and database application programs should be available to the science student (Sigismondi & Calise, 1990). Students create reports with charts, graphs, or other graphics to accurately represent their research.

Information can also be delivered to learners via videotape, videodisc, and film. The science teacher has luckily found many uses for videodiscs. These discs contain vast amounts of data, in the form of text, still images, and video. This information can be used to augment lectures and discussions and can be integrated into student or teacher-produced multimedia. They have become an easily accessible database of valuable images.

Other software packages are available that can be used as tutorials or drill and practice exercises. Tutorials help students who are lagging behind the regular group (Greenbowe & Burke, 1995). Quizzes and tests can be produced, delivered, and graded by the computer. Instructional television, generally delivered by public stations or cable, is an invaluable tool for delivering real science to students. Every science room needs a television, connected to cable, and a videodisc player and VCR. These technologies are readily available and very easy for the science teacher, and learners, to use.

Meeting the Needs of Students with Disabilities

All the technology in the world is inconsequential if it is not used properly, leaving some students out. Kumar & Wilson (1997) present several startling facts. Sixty-nine percent of students with learning disabilities receive a D or lower in high school science classes. Forty-two percent of special education teachers have no training in science. Thirty-eight percent of children in self-contained classrooms get absolutely no science instruction. In today's science classroom, a wide variety of learners are present. Technology can help bridge the gap between disabled students and the norm. Kumar & Wilson (1997) describe several ways that teachers can use several strategies to reach the learning disabled student. They include developing expert tutors, using pictures, video, multimedia, and animation to make small steps in the student's learning and provide specific types of feedback. Anchoring instruction by using videodiscs with real life situations may provide some context for these students. Integrating science with other subjects may make all the disciplines more important to the learner. Reducing cognitive load on working memory allows them to work with one concept or variable at a time. Quiet work areas and tutored lessons aide in delivering instruction to the disabled learner (Kucera, 1993). Technology and the information superhighway can potentially help with these strategies. Unfortunately, these tools are generally biased against the learning-disabled.

Learning disabilities are not the only problems facing some science students. Students that are visually challenged require special technological advances to keep pace with traditional students. Enlarged text and graphical displays, voice outputs, or Braille displays may be useful. A scanner with optical character recognition which reads text to the learner using a synthetic computer voice is another possibility (Kucera, 1993).

Science is a subject that develops thinking and problem solving skills. The discipline enhances the affective attributes, such as attitude towards the world, for students with learning disabilities. Computer technology could provide cognitively challenging environments for the development of analytical, reasoning, and critical thinking skills among disabled students. Technology may also motivate and interest the students with these problems (Kumar & Wilson, 1997). Teaching to the disabled is an important consideration when integrating technology into the science classroom.

National Standards

The National Science Education Standards (1996) have a definite standard for technology use in the science classroom. One particular content standard refers to the development of inquiry skills in science. Techniques included in this development include the use of scientific investigation, instruction designed to produce cognitive and manipulative skills, and the formulation of scientific explanations on the part of the learner. One fundamental component of the standard is described as using technology to improve investigation in science. A variety of technologies should be used, including the use of computers for the collection, analysis, and display of data (National Science Education Standards, 1996). The government backs the integration of technology into science education. State and local entities show great interest in technology in education. Although these groups control most of the funding for educational reform, they do not necessarily provide the incentive to change science education. The learners are most important, and schools can improve in their delivery of instruction by integrating technology into science education.

CHAPTER FOUR

Conclusion

The focus of science educators today is different from past eras. The content of basic biology, chemistry, and physics courses has changed little in the past several years. Most new advances are above the level of knowledge needed by the high school student. These learners, though, have changed. Technology is a tool by which these young people live their lives; education must adapt to fit into this information age.

Change in science education is an on-going process. The typical science laboratory classroom can be altered into an interactive learning environment of discovery. Evolution of the classroom starts with the teacher. It is recommended that the teacher should adapt from being a bearer of information to a facilitator of learning. Teaching methods should shift the focus from rote learning to the constructivist view, one of discovery and hands-on learning. Technology is the road by which this change can occur.

Careful planning, perhaps by using an instructional development model, is recommended as the best way to start in integrating technology with learning. A long-range strategic plan can help to offset some of the funding and facilities considerations. An important thing to consider is that technology integration is a process of change, and will not happen quickly. A careful analysis, including a needs- assessment, takes time. The diversity of the learners needs to be examined. Adoption and evaluation of technology is also an important aspect of integration into the science curriculum.

This paper has focused on the process associated with changing the typical science classroom into a new, interactive learning environment. Special mention has been made to relate this change to the national standards. The research question deals with the selection and integration of available technologies into science education. The number of different technologies available to education is vast. The need for change is apparent, due to the evolution of our nation's youth. If we are to prepare students for life in the next century, technology must become a vital component of our educational system. The responsibility ultimately lies on the shoulders of the science educator, who must evolve in the mode and method of instructional delivery. Technology, because of the advancements of science, has changed our lives. Teaching, because of the advancements of technology, is now ready to change science education.

References

Amend, J., Furstenau, R., Howald, R., Ivey, B., and Tucker, K. (1990). Computer series, 113. An integrated workstation for the freshman laboratory. Journal of Chemical Education, 67, 333-336.

Bisbee, G. and Kaiser, C. (1997). Milkweed seed dispersal: A means for integrating biology and physics. The American Biology Teacher, 59, 426-427.

Boone, W. (1996). Developing distance education classrooms. The Technological Horizons in Education Journal, 24, 61-63.

Brown, P., Coleman, S. and Fischback, K. (1996). Hypermedia research projects. Showcase on educational technology in Iowa schools. Cedar Falls, IA: Iowa Educational Technology Training Institute.

Byman, K. (1996). ICN electronics-based lab course. Showcase on educational technology in Iowa schools. Cedar Falls, IA: Iowa Educational Technology Training Institute.

Christensen, J. (1996). Interactive Mars Base Project. Showcase on educational technology in Iowa schools. Cedar Falls, IA: Iowa Educational Technology Training Institute.

DeWeerdt, M. (1996). Computer-based laboratory technology in action. Showcase on educational technology in Iowa schools. Cedar Falls, IA: Iowa Educational Technology Training Institute.

Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned. Educational Leadership, 32, 12-18.

Elliot, I. (1995). Taking the fast lane on the information superhighway. Teaching pre K-8, 26, 34-39.

Friedler, Y., Merin, O., and Tamir, P. (1992). Problem-solving inquiry-oriented biology tasks integrating practical laboratory and computer. Journal of Computers in Mathmatics and Science Teaching, 11, 347-357.

Greenbowe, T. and Burke, K. (1995). Distance education and curriculum change in introductory chemistry courses in Iowa. Techtrends, 40, 23-25.

Hanson, D., Maushak, N., Schlosser, C., Anderson, M., Sorenson, C., and Simonson, M. (1996). Distance Education: Review of the Literature, 2nd ed. Ames, IA.: Research Institute for Studies in Education.

Hart, F. (1998). A microcomputer-based phase-change experiment. The Physics Teacher, 36, 98-99.

Henderson, C. (1998). Measuring the forces required for circular motion. The Physics Teacher, 36, 118-121.

Kucera, T. (1993). Teaching Chemistry to Students with Learning Disablilities, 3rd ed. Washington, D.C.: American Chemical Society.

Kumar, D. and Wilson, C. (1997). Computer technology, science education, and students with learning disabilities. Journal of Science Education and Technology, 6, 155-160.

Martin, E. and Rainey, L. (1993). Student achievement and attitude in a satellite-delivered high school science course. American Journal of Distance Education, 7, 54-61.

Matray, P. and Proulx, S. (1995). Integrating computer/multimedia technology in a high school biology curriculum. American Biology Teacher, 57, 511-520.

Mirabito, M. (1996). Establishing an online educational program. The Technological Horizons in Education Journal, 24, 57-60.

National Science Education Standards. (1996). Washington, D.C.: National Research Council.

Newby, T., Stepich, D., Lehman, J., and Russell, J. (1996). Instructional technology for teaching and learning. Columbus, OH: Von Hoffman Press.

Pool, T., Blanchard, S., and Hale, S. (1995). From over the internet: Users discuss a new direction for learning. Compters in Education, 7th ed. Guilford, CT.: Annual Editions.

Powers, M. (1989). Laboratory connections: Review of two commercial interfacing packages. Journal of Computers in Mathematics and Science Teaching, 8, 73-76.

Project 2061. (1993). Benchmarks for Science Literacy. New York: American Association for the Advancement of Science.

Rhoton, J. and Sternheim, M. (1993). Integrating technology into the science classroom. Sourcebook for Science Supervisors, 4th ed. Arlington, VA: National Science Teachers Association.

Richards, J., Barowy, W., and Levin, D. (1992). Computer simulations in the science classroom. Journal of Science Education and Technology, 1, 67-80.

Shapiro, W., Roskos, K. and Cartwright, G. (1995). Technology-enhanced learning environments. Computers in Education, 7th ed. Guilford, CT: Annual Editions.

Sigismondi, L. and Calise, C. (1990). How-to-do-it. Integrating basic computer skills into science classes. American Biology Teacher, 52, 296-301.

Sunseri, L, McClure, J., Kilburg, C., and Hettinger, C. (1996). Kids doing science (KIDS). Showcase on educational technology in Iowa schools. Cedar Falls, IA: Iowa Educational Technology Training Institute.

Wagner, G. (1998). The 100-meter dash: theory and experiment. The Physics Teacher, 36, 144-146.

Walsh, J. and Reese, B. (1995). Distance learning's growing reach. The Technological Horizons in Education Journal, 22, 58-66.

Yager, R. (1995). Science-technology reform via distance education technology. Techtrends, 40, 19-22.