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Rationale for and Examples of Internet-Based, Software, and Hardware Technologies That Can Be Integrated into the Science Classroom

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Chapter One: Introduction

Problem Statement

A century ago expectations of American high school students were vastly different from today, where recitation of both works by famous authors and scientific facts coupled with some basic knowledge of arithmetic were the accepted norm (Roschelle, Pea, Hoadley, Gordin, & Means, 2000). Since then, curriculum standards have experienced a number of changes and revisions, especially in the field of science education (Hurd, 2002).

Throughout human history, cultures worldwide have contributed both knowledge in the realm of science and technological innovations to the global community (NRC, 1996). During the 20th century, and continuing into the 21st century the world experienced a number of events, such as the Great Depression, both World Wars, widespread famine in Africa, and the AIDS pandemic that resulted in a multitude of new technological innovations. These technologies included stainless steel, antibiotics, television, the atomic bomb, radar, lasers, artificial hearts, genetically modified agricultural products, the World Wide Web, protease inhibitors and the hybrid automobile (Bellis, n.d.). In an attempt to keep pace with technological advancements and in order to prepare American youth for the changeability of the global market and workplace, education standards at both the state and national levels have been restructured to incorporate technology into the curriculum (Roschelle et al., 2000). Not surprising, the strongest push to infuse technology into the curriculum has occurred in the sciences, perhaps due to the often (incorrect) synonymous association of the two fields (American Association for the Advancement of Science [AAAS], 1989; AAAS, 1993; NRC, 1996).

Although they are not one and the same, the interconnectedness between the fields of science and technology is irrefutable. Indeed, the NRC (1996) states that the relationship connecting the two fields is "so close that any presentation of science without developing an understanding of technology would portray an inaccurate picture of science" (p. 190). Likewise, in its publication *Science for All Americans* the AAAS (1989) states that scientific understanding, through the detailed knowledge of the principles that underlie how the natural world works, contributes significantly to technology. The benefits to integrating technology in the science classroom are therefore fairly obvious but first one must inquire, "What is technology, exactly?"

Definition of Terms

Technology is a concept that encompasses many diverse meanings which can complicate the integration process because there is no one *exact* definition (for instance, *"How can we incorporate technology if we don't know what it is?"*). Broadly defined, technology is "a means for accomplishing work" (Moore, 2006, p. 401) or "anything people do to modify the natural world to meet human needs" (Rose, Gallup, Dugger, & Starkweather, 2004, p. 1). Technology has also been used to describe: (a) tools or innovations that people utilize or manipulate, (b) human activities such as industry or agriculture, and (c) processes like genetic engineering or voting (AAAS, 1993). And to many, a modern definition of technology has come to mean the machines and tools that man has created, often referring to computers and the Internet (Rose et al., 2004, p. 1). In fact, Gallup surveys of Americans conducted in 2001 and 2004 for the International Technology Education Association found that two-thirds of survey respondents indicated that the first thing they thought of when the word "technology" was mentioned was computers (Rose et al., 2004). Once a more concrete understanding of the term technology is reached (based on the needs and context of the situation) the next question that may come to mind is, "Why should we incorporate technology into the science education curriculum?"

Rationale

The movement for technology integration has intensified in the last half of the 20th century and the beginning of the 21st century, due in large part to the declining cost and increasing availability of computers and associated media. In a study conducted in 1999 by the National Center for Education Statistics (NCES), most teachers surveyed reported having one or more computers in their classrooms. However, that study also found that teachers from schools with higher poverty concentrations (based on free or reduced lunch percentages) were less likely to have access to computers in their classrooms. Fortunately this trend seems to be on the decline and as a consequence, the student-to-computer ratio is improving (Angeli, 2005). Results of a more recent NCES study conducted five years later (2004) found nearly 93% of instructional rooms (which includes classrooms, libraries, and labs) had Internet access, which implies that those instructional rooms had at least one computer. Therefore certain aspects of technology are becoming more readily available but the mere fact that they are present in the classroom does not mean that they are used correctly or that they are even understood by those incorporating them (Mistler-Jackson & Songer, 2000).

The implications of technology in the classroom are far-reaching and are not restricted to skills associated with computers alone. Benenson (2001) states that technology is commonly found everywhere, in all aspects of daily life. In other words, one is hard pressed to find places where technology is not instituted or used. The AAAS (1989), in *Science for All Americans* describes the relationship between humans and technology even more intimately:

> As long as there have been people, there has been technology. Indeed, the techniques of shaping tools are taken as the chief evidence of the beginning of human culture. On the whole, technology has been a powerful force in the development of civilization, all the more so as its link with science has been forged...In today's world, technology is a complex social enterprise that include not only research, design, and crafts, but also finance, manufacturing, management, labor, marketing, and maintenance. (p. 25)

Technology, as we understand it today, is more than just knowledge of computers. Its impact has ramifications on a global scale in numerous ways including socially, ethically, and economically. Due to the competitive nature of the workforce and global markets, Okojie and Olinzock (2006) believe that it is the responsibility of educational institutions to provide American students with technological experience before they leave high school. An American education without technology would not be adequately preparing our students for a future in our modern world – an injustice, at the very least, to our students *and* society.

Chapter Two: Literature Review

With most of the current state and national standard agencies encouraging technology integration, administrators and teachers are being required to update and reconfigure their curriculums and lessons. Especially in the sciences, science literacy is ranking top amongst expected outcomes of student learning, and understanding technology is crucial to science literacy (Cajas, 2001). The AAAS (1993), in its *Project 2061: Benchmarks for Science Literacy* states that the mission of schools and administrations is to facilitate learning through the use of technology by threading technology education into the curriculum. This task can be a difficult one, especially for the teachers who have limited or no experience with technology. The unfamiliarity associated with the process of integration can bring about anxiety and negative opinions about technology (Cantrell & Knudson, 2006; Gado et al., 2006; Hernandez-Ramos, 2007; Pedersen & Marek, 2007; Watson, 2006). Ultimately this can lead to a haphazard attempt at integration in a "you told me to include technology so I did" manner, where benefits of the experience are questionable. Implementing technology in the classroom should serve a purpose other than just to simply use it; it should also complement the experience and enhance the learning environment for students (Cantrell & Knudson, 2006; Henriques, 2002; Hernandez-Ramos, 2007; Pedersen & Marek, 2007; Roschelle et al., 2000).

Traditionally, in secondary education, curriculums based on the standards have sought to offer students experience with technology in three ways: (1) as a separate subject, a "technology class," which has often been referred to in the past as "shop" (Benenson, 2001), (2) as "keyboarding" in which basic computer skills are taught (Cajas, 2001), and (3) as an integrated part of the main subject areas (math, science, English, and social studies). The purpose of this paper focuses on the latter by addressing two main questions:

1. ***What types** of technologies are available for use in the science classroom?* There is an endless list of technologies available for use in the science classroom and to the teacher with limited experience with technology (which can include both preservice and in-service teachers alike) the task of integration can seem daunting. This paper looks to qualify and describe three main types of science classroom technologies: Internet-based, software, and hardware.

2. ***How** can technology be integrated into the science classroom?*

With so many technological avenues and devices to choose from, it can be difficult to devise novel ways to integrate them, keeping in mind that the most appropriate technology integration is in a manner that can benefit the learning experiences for the students. This paper gives examples of how to integrate technologies from the three main types of Internet-based, software, and hardware technologies.

As the term "technology" encompasses many definitions and includes the use of everyday tools, a computer, certainly, is considered technology but, according to Benenson (2001), "no more so than the box it came in, the table it sits on, or the pencil and yellow pad it replaces" (p. 731). To clarify, for the purpose of this paper, unless stated otherwise, "technology" will indicate computers and associated media, digital and electronic devices, and the *use* of these varied devices.

Benefits of classroom technology integration

When it comes to modern (computer/electronic) technology, it is not uncommon to observe parents commenting on the skills of their sons and daughters. Children are introduced to and interacting with technology at very young ages and by the time they enter kindergarten they are veteran users of technology (AAAS, 1993; Benenson, 2001). And, as Krajcik (2001) notes, the use of technology is integral to students' lives and creates a more meaningful experience for them. It makes sense then, that inclusion of technology in the everyday experiences of the science classroom would be encouraged.

Classroom technology integration can be classified as both a learning *and* instructional tool. As stated by Okojie and Olizock (2006):

> ...technology is perceived as any tool, material, device, or equipment adapted for educational use and for the purpose of enhancing teaching/learning. Thus, technology integration is viewed as a process, and a resource through which teaching/learning become active, engaging and meaningful. Integrating technology into instructional delivery encompasses a complex network of activities and process...It also involves the selection of suitable technology based on the learning needs as well as ability of teachers to adapt such technologies to fit specific learning tasks. (p. 37)

Using multimedia software to augment a lecture, students using handheld probe devices to collect and analyze data, and viewing cell division via a microscope camera displayed through a projector are all ways of integrating technology into the science classroom.

Due to the unique and complex nature of technology as well as associated costs, few well-structured longitudinal studies that document the effects of technology have been developed (Clark, 2006; Hennessey, Deaney, & Ruthven, 2006; Mistler-Jackson & Songer, 2000; Roschelle et al., 2000). However, there have been documented advantages of technology integration in the science classroom and according to many researchers in the field these benefits fall in the areas of:

- Ease of data collection and manipulation
- Motivation and participation in "real science"
- Collaboration and social interaction
- Self-efficacy and empowerment
- Academic achievement

Ease of data collection and manipulation

By the time they reach middle school, many students are familiar with and able to manipulate a number of data collection technologies. Calculators, balance scales, and thermometers are instruments that most students typically encounter early in their educational careers as staples of the science classroom experience. Traditionally, participation in the science classroom involves busywork and downtime, particularly when data collection is involved. ("Busywork" will be used to describe in-class activities when students are recording or plotting data and "downtime" will be used to indicate time spent waiting for results, for other classmates to catch up, etc.) Oftentimes the results of the students' labor has to be plotted, graphed, or otherwise tabulated (either in class, if time permits or outside the classroom, as homework) and brought back for discussion the next day (Roschelle et al., 2000). This creates a lag between the experience itself and the discussion, which may impact the extent of connection between the topics or concepts.

Modern technology has created a number of tools that can reduce the amount of downtime and busywork. These technologies have the ability to increase not only the speed and efficiency of common procedures but also improve the accuracy of the end products and their presentation (Ruthven, Hennessy, & Brindley, 2004). Such devices like probeware attached to portable technologies and computer simulations can allow students almost instantaneous access to information by reducing the amount of time students spend gathering the data and when they begin to analyze and interpret it (Roschelle et al., 2000). Instruments that are connected to specific computer software can also allow students to visualize the data in numerous forms, thereby contributing to a more robust overall picture of the activity and its findings (Hennessy et al., 2006; Krajcik, 2001; Novak & Gleason, 2001). A reduction in busywork and downtime can potentially offer up more instructional or discussion time to facilitate students' understanding of concepts and construction of knowledge. These technologies can also present unique situations in which experiments can be performed or simulated in a classroom where, because of cost, danger, time, or other factors, the activities might not otherwise be feasible (Hennessy et al., 2006; Smetana & Bell, 2006). Another advantage of using such technologies is the potential for creating increased student involvement and motivation.

Motivation and participation in "real science"

One of the key components to getting students involved in the learning process is through motivation. Introducing technology into the classroom can have profound effects on motivation due to a variety of factors. First and foremost, the inclusion of technology in the classroom can motivate students based on the "coolness" or enjoyment factor alone by introducing more fun and exciting activities and procedures that require less busywork (Liu, 2005; Ruthven et al., 2004). In one study students were so interested in the use of technology (digital cameras) that they actually came in outside of class, during their own free time, to work further on the laboratory project (Tatar & Robinson, 2003).

Another way of affording students the ability to learn science in a more motivating and meaningful way is by connecting them to the "real world," the realm beyond the school walls. Students who see application in schoolwork to their own lives tend to take more ownership of their data (Novak & Gleason, 2001). Integrating technology into the classroom allows students to experience what "real" scientists do on a daily basis by enhancing the authenticity of the tasks and quality of the experience (Klopfer, Yoon, & Perry, 2005; Novak & Gleason, 2001; Ruthven et al., 2004; Smetana & Bell, 2006).

Yet another way of increasing motivation through the use of technology is participation in computer-based networking and collaborative activities.

Collaboration and social interaction

Increasing access to the Internet means more students will have instantaneous access to a cornucopia of facts and information and real-time data. The Internet also provides a unique opportunity for students and educators to communicate with people from all over the world. With email and other networking avenues, some educators have harnessed these collaborative opportunities and augmented their social learning environments by providing their students with a means of accessing the real world (Mistler-Jackson & Songer, 2000). Roschelle et al. (2000) found that students who participated in collaborative computer-connected learning networks showed "increased motivation, a deeper understanding of concepts, and an increased willingness to tackle difficult questions" (p. 81). In one study, researchers used multimedia biotechnology simulation software called that also included an integrated Internet conferencing system (Bergland et al., 2006). After performing genetic simulations, students were required in one instance to create detailed Web page posters and then discuss the results with one another via Web conferencing. In the second situation, simulations were performed as before (with the biotechnology simulation software) but with posters made of cardboard and results that were discussed during a live, in-person conference. When compared to using cardboard posters and in-person conferencing, 65% of students felt they learned more from the Web-based poster and conference sessions.

With the use of the Internet and networking technologies, students can communicate with knowledgeable professionals in the different fields of science as well as exchange data and experimental information with peers from essentially anywhere, both on a national and international level (Krajcik, 2001). For example, the Kids as Global Scientists (KGS) program is an 8-week atmosphere science networking program where middle school students use an Internet software program to study general weather topics with students and scientists across North America (Mistler-Jackson & Songer, 2000). A large component of the KGS program is to provide a collaborative atmosphere where students collect local data and share it with participating peers and meteorologists.

Part of the sharing process involves discussing and analyzing the data and debating the events and outcomes. And, as many scientists and educators alike can attest, healthy debates provide an important avenue for students to develop a deeper understanding of science (Krajcik, 2001).

Another benefit to the KGS program the researchers found was an increase in self-efficacy and empowerment with the students involved with the project (Mistler-Jackson & Songer, 2000).

Self-efficacy and empowerment

As defined by Bandura (as cited in Mistler-Jackson & Songer, 2000), self-efficacy is "one's personal beliefs about their performance abilities" (p. 463). Additionally, Mistler-Jackson and Songer (2000) define empowerment as "often used to reflect feelings of self-efficacy that positively influence one's accomplishments" (p. 475). Some of the studies that have been conducted involving technology have been thought to show an increase in both self-efficacy and empowerment on the part of the student participants of all ages, from child to adult (Hyun & Davis, 2005; Mistler-Jackson & Songer, 2000). In a study conducted by Hyun and Davis (2005), kindergarteners immersed in a technology-rich classroom were shown to have a higher degree of self-confidence, based on interactions and discussions with fellow classmates. In another example, preservice teachers using handheld computers and probeware in a science methods course reported higher feelings of self-confidence and self-efficacy with technology after being exposed to it in their course (Gado, Ferguson, & Van't Hooft, 2006). (Technology exposure for preservice and experienced teachers, an obstacle to integration, will be discussed in further detail later.) The last section, academic achievement, is perhaps the least well-described area associated with technology integration.

Academic achievement

Information on improvements in academic achievement was not generally found explicitly, but there were some exceptions (Liu, 2005; Ruthven et al., 2004; Taylor, Castor, & Wells, 2004). A study conducted by Ruthven et al. (2004) implied that the use of technology contributed to enhanced scholastic achievements. In another study conducted by Taylor et al. (2004) it was found that exam scores coupled with student responses (72% stating they learned "a lot" with the technology-integrated units) indicated that students learned more when technology was integrated than when it was not.

While increases in academic achievement are arguably an important goal researchers and educators would like to attain, the impact of technology integration should not be measured solely in terms of academic success. It is important to keep in mind that accomplishment can also be recognized as the acquisition or development of skills. For instance, a study conducted by Novak and Gleason (2001) found that the use of technology in the classroom further enhanced the students' practical problem-solving skills.

The above examples are just a few of the benefits that are currently found in the literature. If technology integration can be such a useful and beneficial supplement to learning, why is it not more widespread and commonplace in the science classroom?

Obstacles to technology integration

Oftentimes fresh and new ideas face barriers when they are first introduced into an environment where existing situations appear to be working – similar to the "if it isn't broken, why fix it?" mentality. It would seem that a similar set of circumstances is occurring with technology integration in the science classroom. Some of the obstacles to technology integration may include:

- Cost of technology
- Access to technology support staff
- Teacher attitudes and beliefs about technology

Cost of technology

While the cost of computers has declined in recent years, providing access for each student in the science classroom can still pose barriers, because of both space constraints (where the equipment is set up or stored) and lack of funding. One could argue that laptop computers are a way to solve at least one of the obstacles (space) but the cost issue still remains a hindrance to implementing their use in the classroom.

A technology that surfaced in the business realm during the 1990s was the PDA, or personal digital assistant. In the beginning, PDAs were both costly and had limited application in classrooms (Pedersen & Marek, 2007). Companies mainly focused on keeping the business world organized, with storage of contacts, personal information, and calendars serving as the main functions of PDAs. Noticing the applicability potential of using this technology in the classroom, many companies capitalized on the idea. Now, PDAs and other mobile handheld computers are more user-friendly, offer a wider variety of options, and are more powerful, with increased computing capabilities and storage capacities which make them attractive for use in the classroom (Franklin, Sexton, Lu, & Ma, 2007; Pedersen & Marek, 2007). Most of all, these devices are becoming more affordable and thus, more available for teachers and students (Franklin et al., 2007; Pedersen & Marek, 2007). And it's not just PDAs; Hernandez-Ramos (2007) discusses the motivation toward the use of digital video technologies as instruments for teaching and learning because of recent noteworthy drops in prices.

With digital technologies becoming a more cost effective option for supplementing the science curriculum, there still remains a certain level of hesitancy with technology incorporation. One reason for this caution is access to qualified and knowledgeable technology support personnel.

Access to technology support staff

As with just about anything, integration of technology into the classroom introduces a plethora of new issues and problems. Computers need upkeep and maintenance, networks are unstable and fickle, software becomes outdated, and portable devices inevitably get bumped and dropped. In short, with all the planning and instructing that teachers do on a daily basis, the last thing they need is another task added to the growing list, especially a task that often requires a certain level of knowledge and expertise.

The tackling of mounting loads of technology issues requires knowledge and experience with specific equipment (Glenn, 1997). Due to lack of funding, schools do not often have the money to support fulltime technology staff, even as the number of classrooms with computers and Internet access grows. In a report by Ronnkvist, Dexter, and Anderson (2000), even though 87% of reporting schools indicted there was someone who served as technology coordinator, only 19% of those coordinators worked fulltime in that role. These staff members reported that their job consisted of a variety of responsibilities, a large percentage of which were not related to supporting technology (Ronnkvist et al., 2000). Those additional roles included classroom instructor (45%), network coordinator (26%), media specialist (16%), and other (13%). Clearly, in order to provide support to an increase in technology integration in the classroom, access to fulltime knowledgeable and qualified personnel is necessary. One method to reducing the amount of technology support requests, however, is ensuring that teachers themselves have backgrounds and experience with technology.

Teacher attitudes and beliefs about technology

Studies involving both preservice and in-service teachers' beliefs surrounding technology integration have generally found pre-study attitudes to be fairly negative and post-study attitudes (after participants had been introduced to and using technology) to be quite positive. The emerging consensus for this trend is that teachers with little or no experience with technology tend to report more negative attitudes, often due to lower degrees of comfort based on high levels of fear and anxiety surrounding its use; this leads to reduced integration efforts (Cantrell & Knudson, 2006; Gado et al., 2006; Hernandez-Ramos, 2007; Pedersen & Marek, 2007; Watson, 2006). In one study of preservice teachers, Gado et al. (2006) found that after requiring students in the science methods course to utilize handheld computers and probeware to augment their science laboratory experience they reported increases in both attitude and self-efficacy towards the incorporation of technology into their future classrooms.

In another study, Cantrell and Knudson (2006) investigated the attitudes of in-service science teachers with regard to technology. This study provided in-service teachers with a professional development opportunity to explore the use of numerous technologies, including handheld global positioning system (GPS) devices and pocket PCs. Prior to the professional development experience many teachers reported negative and stressful attitudes about technology. One participant even commented, "If pencil and paper were good enough for Lewis and Clark, then they are good enough for me" (Cantrell & Knudson, 2006, p. 17). However, by the end of the study many of the participants felt that their experience with the technology was beneficial and they felt more comfortable with its use; as a result they were more likely to consider using technology in their own classrooms. Thus, to increase a teacher's desire to integrate technology into the science classroom, s/he must develop a more positive mind-set towards its use (Okojie & Olinzock, 2006).

Due to the existing technology integration curriculum requirements, access to up to date information is crucial for both preservice and in-service educators. The goal of this paper it to assist science teachers in gaining access to the knowledge of classroom technologies by providing a glimpse into some technologies that are currently available. This paper will briefly introduce and describe select Internet-based, software, and hardware technologies that can be used in the modern science classroom. For each technology examined an example will be used to illustrate a scenario in how the technology might be integrated.

Chapter Three: Application

There are numerous ways to integrate technology into the science classroom as a means of augmenting the learning environment for students. Whether simply using a Web site to gather information on current cancer research or sampling water conditions of a roadside stream with a handheld probe device, technology can enhance the quality of the science class experience in meaningful ways, for both the teacher and the students. This chapter will focus on qualifying three main types of technologies used in science classrooms: Internet-based, software, and hardware technologies. Each of the three general technologies is broken down further into select technologies representative of each category. An overview of each common technology is given, followed by an example of how to integrate the specific technology.

Internet-based technologies

The Internet was first proposed in the 1960s as a project for the United States military (Bettelheim, 2001). Its purpose was to connect government and university researchers and provide an avenue through which authorized participants could stay in contact with one another and work together to complete projects. The Internet remained exclusively for the use of government, research and higher education personnel until the government cut funding and the Internet became open to commercial use in the early 1990s. Coupled with the invention of email in 1972, the Internet has increased exponentially in its use and popularity (Rosenzweig, 1998). The creation of the World Wide Web [Web], in conjunction with Web browsers, has lead to the average person's ability to navigate the multitude of information found on the Internet. For simplicity, both the terms "Internet" and "Web" will be used to describe modern access to information found via the Internet.

As access to the Internet continues to widen, both at home and in schools, students are becoming more familiar with navigating the world of cyberspace. An advantage to using the Internet as a classroom technology tool for instruction and learning is students (and teachers) generally know how to maneuver around the Internet, at least at basic levels. Therefore, teachers do not need to spend excessive amounts of class time with detailed explanations and directions. In this section, five Internet-based technologies will be presented:

- Web site evaluation
- Web sites as instructional resources
- Web sites as content resources
- WebQuests
- Email and global communication

When incorporating the use of the Web into classroom activities it is important to keep in mind that as access to the Internet (and the abundance of information it contains) is readily available, almost anybody can create and publish Web sites regardless of their education, qualifications, or expertise. This can lead to development of sites laden with personal biases, misrepresentation of facts, people, and events and even inaccurate information. Both teachers and students alike must use caution when gathering data from the Internet and one way to help ensure a Web site is a reliable source is through proper evaluation of the site.

Web site evaluation

Technology overview. When the Internet became commercially available in the 1990s, in general, the only people who could create and publish Web sites were those well-versed in HTML programming. However, with the creation of both free and commercial Web page editing and development software (covered in the section entitled *Software technologies*), the capability to easily and quickly design one's own Web site now exists at the click of a mouse. As a result, when using Web sites as sources of information, users should verify that they are reporting accurate and reliable data by evaluating the site's content.

Generally there are three main areas (minimally) that should be assessed when evaluating a Web site: author(s) credibility, accuracy of the content, and currency (how recent) of the information. A fairly quick and simple way to determine the effectiveness of a Web site is via a checklist. Figure 1 shows an excerpt taken from a Web site evaluation developed by Schrock (1995). Evaluations can be used by both teachers and students to determine which sites are the most appropriate for gathering information. (See Appendix A for another example of a Web site evaluation.)

Integration idea. The ability to evaluate a Web site's content is a skill that should be taught to all students. Indeed, if students will be using the Internet often throughout the course of the school year, the skills to evaluate Web sites should be modeled early. This can be achieved either by having students select at least three Web sites (or the educator can pre-select a handful of sites), and then have the students complete a checklist. In the event that sites have been pre-selected, choosing sites with well-written content, average content, and poorly-written content is suggested so students can see the differences among them.

CONTENT: As you look at the questions below, put an X in the YES or NO column for each.	YES	NO
Is the title of the page indicative of the content?		
Is the purpose of the page indicated on the home page?		
When was the document created?		
If there is no date, is the information current?		
Does up-to-date information matter for your purpose?		
Would it have been easier to get the information somewhere else?		
Would information somewhere else have been different? - Why or why not?		
Did the information lead you to other sources, both print and Web, that were useful?		
Is a bibliography of print sources included?		
Does the information appear biased? (One-sided, critical of opposing views, etc.)		
Does the information contradict something you found somewhere else?		
Do most of the pictures supplement the content of the page?		

Figure 1. Excerpt of a Web site evaluation checklist taken from Schrock (1995).

This activity may need to be performed more than once to aid students in building skills for selecting quality sites. Once students see the disparity in quality of information, hopefully they will be better equipped to select Web sites with more accurate and appropriate content in the future.

Web sites as instructional resources

Technology overview. As mentioned, with current resources anyone can publish a Web site, the consequences of which can be both good and bad. One positive outcome of this publishing freedom is the online sharing and collaboration of peers and colleagues, especially in the teaching field. While some sites require registration along with payment, many Web sites offer myriad of resources for teachers of all subjects and all grade levels for free. These Internet resources provide not only lesson plan samples and templates but also advice on classroom management, ideas for alternate lab exercises (which can be useful when budgets are tight), links to other useful sites, and even technology integration resources. In addition, many of these instructional resource Web sites provide numerous avenues of communication between and among participants, including email, bulletin boards, and chat rooms. (See section entitled *Email and global communication.*)

Integration idea. While integrating these instructional Web sites directly may not be the most effective for students *per se*, garnering information from them can lead to a host of ideas for new lessons. For instance, Access Excellence (http://www.accessexcellence.org/), a national education program hosted by the National Health Museum, provides an abundance of links to interesting sites including x-ray images of human bones and Biology Education Online, a free online resource provided by the National Science Foundation (NSF). Biology Education Online is a peer reviewed journal that allows teachers to submit lessons and labs for publishing. Each lesson or lab is reviewed by a panel of experts that evaluate and revise (if necessary) the activities. Activities found on the Biology Education Online site span grade levels from middle to high school and while they are generally based on biology and health sciences, interdisciplinary ideas can also be found, “Beowulf in the Bog” being a prime example. This lesson plan allows students to investigate certain scientific aspects of the natural environment while experiencing a classic piece of literature set in the same type of environment.

Another useful resource is a site called School Notes (http://www.schoolnotes.com/), a school-to-home communication platform. The site allows teachers to communicate any number of thoughts or ideas to parents and students alike. One popular use of the School Notes Web site is for posting homework. To access the posted information users need only the zip code of the school (registration is only required by the teacher). Both students *and* parents can therefore have access to what work is due and when. Appendix B lists other Internet sites that offer a number of instructional resources, with a focus on biological sciences.

Web sites as content resources

Technology overview. Much like using Web sites as instructional references, they can also be great sources of content information (and many offer instructional resources as well). Although textbooks and other print material have been the backbone of many classes, information in the sciences literally can change on a daily basis. And while it has already been established that there can be misleading and erroneous information, the Internet is a great source of current, accurate information as data will likely be updated before new textbooks can be purchased by school districts.

Besides providing great text resources, the Internet is also a wonderful "one stop shop" when it comes to gathering information about a topic. In addition to text the Internet usually provides a range of multimedia pieces, including pictures, sounds, and even videos. Oftentimes these multimedia files can be downloaded and saved for use at a later time.

Integration idea. Of the many dissection simulations on the Internet, one of the more professional-looking sites is the cow's eye dissection from Exploratorium, a Web site from the museum of science, art, and human perception at the Palace of Fine Arts (http://www.exploratorium.edu/). The site is student-friendly and has a number of multimedia facets, including photographs, diagrams, and both low and high resolution videos. One way of integrating the use of the Exploratorium's cow eye dissection would be to have students go through dissection virtually before actually performing the dissection, a complementary activity to augment the actual event. By using the virtual dissection as a precursor to the real one, students will be familiar with some of the more obvious structures that they can then search for during the actual procedure. This would also be a great tool to use as a dissection opportunity for students who cannot participate in the actual procedure due to religious or moral dilemmas.

WebQuests

Technology overview. One of the more popular classroom activities involving the Internet is the WebQuest. WebQuests are activities in which participants use the Internet to gather information about any number of given topics (Gaskill, McNulty, & Brooks, 2006). Generally there are two levels of WebQuests: those which are characterized by basic "search and find" activities that span only a class or two to the more involved projects that require teamwork and numerous class periods.

The basic WebQuest usually entails a teacher finding a few sites regarding a specific topic who then creates a worksheet with questions that students answer by searching the sites. The more advanced WebQuest, on the other hand, is a larger project usually more open-ended and based on the constructivist learning theory. These activities commonly involve teamwork with responsibilities broken down into five sections: introduction, task, process, evaluation, and conclusion. While advanced WebQuests also utilize information found on existing Web sites many educators will choose to create their own Web pages that outline and describe the activity. These WebQuests can range from simple sites created with free Web page editing or development software to professional sites, like the Expedition Susquehanna, an environmental investigation created by Tom Ackerman of the Chesapeake Bay Foundation (http://www.cbf.org/). Fortunately, while this type of WebQuest takes more time and planning to develop and implement, many authors choose to share the products of their labors. Existing WebQuests (and templates for creating one's own activity) can be found at the WebQuest Portal (http://www.webquest.org/), a site created and maintained by the educator who is often credited with the invention of the WebQuest, Bernie Dodge.

Integration idea. Instead of using the traditional instructional methods to teach genetics students can complete a WebQuest. An activity already created for middle school science, the Baffling Baby Mix-up, can be found at http://www.uni.edu/schneidj/webquests/spring05/baby/index.html. This WebQuest can be modified to be used at different times of instruction. For instance, to introduce the topic of genetics students could complete the first activity, which discusses DNA. After giving notes have students perform an actual DNA extraction with common household chemicals (http://learn.genetics.utah.edu/units/activities/print-and-go/dnaextract.cfm). Prior to completing the Baffling Baby Mix-up WebQuest, however, notes on Punnett squares and probability should be given as this is an area where students tend to be confused.

Email and global communication

Technology overview. Electronic mail, or email, along with the Internet, has made the world a considerably smaller place. Instead of taking days, weeks, or months for information to be sent across the globe, communication is now almost instantaneous. A researcher in the jungles of Madagascar (provided s/he has an Internet connection) can send documents and data to the home lab in Maryland practically the moment they are collected. Later that evening (again, contingent on the Internet connection) the researcher can send correspondence via email to colleagues or family members, or s/he can arrange for a conference via the Web to discuss the day's findings. This same communication technology can be applied in any classroom with an Internet connection, facilitating both scholarly and social endeavors.

In addition to email, a variety of other avenues of communication can be facilitated via the Internet. Instant messaging programs, chat rooms, bulletin boards, and Web conferencing sites are all technologies that can be used by students in the classroom. And, depending on the hardware technology available, conversations can take place with just an audio feed or both visual and audio feeds can be employed for a face to face experience. Students can conceivably communicate with students as well as researchers from anywhere in the world.

Integration idea. While the thought of developing a science project that involves global collaboration may seem daunting, there are Web sites that can facilitate the process. For example, the Global Schoolhouse (http://www.globalschoolnet.org/index.html) is an Internet site that enables participants worldwide to "meet" virtually to interact and communicate to plan meaningful project-based learning opportunities. In order to demonstrate the variation in soil composition between tropical rainforests and deciduous forests a project could be developed between a school in western New York and a school in Hawaii. Students could collect data over a certain period of time and then analyze their data. With the assistance of Web conferencing students would be able to present and discuss their findings, an academic and socially stimulating activity.

Software technologies

To differentiate between the two, *software* is defined as the computer program or application that is run by the *hardware*, the physical machine. The software usually consists of a set of instructions that dictate how the hardware runs or what work it can perform. There are a number of software technologies that can be integrated into the science classroom, including general computer software like word processing programs, computer simulations, and even video games. This section will cover the following software programs or applications:

- Web editing/development software
- EcoBeaker HS®
- Case It!
- BioLab® dissection simulations
- Nano Legends™

Web editing/development software

Technology overview. As indicated in the section on *Internet-based technologies*, the use of Web sites can be integrated into the science classroom in a variety of ways. Previously, the development of Web pages for one without a background in Web programming (like HTML, PHP, CSS, among others) used to be near impossible. However, in recent years the invention of Web editing and development software has enabled those with limited or no experience in Web programming to create and publish Web sites. Now there are a number of Web editing and development software programs available for everyone from beginners to professionals. And with WYSIWYG (which stands for "What You See Is What You Get") HTML editors, users can create Web pages as easily as creating word processing documents. One of the most well known Web development software applications is Adobe® Dreamweaver® (http://www.adobe.com /products/ dreamweaver/). Although this software can be quite expensive, it can produce high quality, professional-looking sites that can serve a variety of uses, for both the teacher and the student (and in some cases, parents and other members of the community). Other more affordable Web editing options include CoffeeCup® VisualSite Designer (http://www.coffeecup.com/designer/) and Namo® WebEditor (http://www.namo.com/products/webeditor_professional.php) which are currently available for less than $100; Nvu (http://www.nvu.com/index.php) and XStandard Lite (http://www.xstandard.com/) are available as free downloads from their respective Web sites.

Integration idea. The creation of Web sites as WebQuests is one use of Web editing/development software that has already been discussed. Another way to integrate this technology into the classroom is for the creation of Web sites for teachers and students. As a teacher it can be a helpful tool to have a Web site where you can post information and resources that students (or parents) can access from home or other off-campus location. Links to interesting Web sites, homework postings, and academic calendars are all examples of information that can be posted to a Web site that could help facilitate communication between the teacher, the students, and their parents. With Web editing and development software, this goal can easily be achieved. Additionally, students may be interested in assisting the teacher with the creation and maintenance of Web sites, which will aid students in gaining valuable hands-on experience with technology.

EcoBeaker HS

Technology overview. EcoBeaker HS by SimBiotic Software (free downloadable demo available at http://www.ecobeaker.com/index.html) is an interactive biology simulation software for use in secondary biology and environmental science classrooms. The software includes ten lab simulations which are broken down into four population biology labs, four communities and ecosystems labs, and two evolution and genetic labs. Each lab consists of background information for both teachers and students, tutorials for teachers and students (including suggestions on how to build a lab around the simulation model), a simulation with a number of variables that can be manipulated, and assessments which students can take and the results can be emailed to the instructor.

Figure 2 shows an example of the graphical interface for one of the ten labs, the famous predator-prey relationships between wolves and moose on Isle Royale.

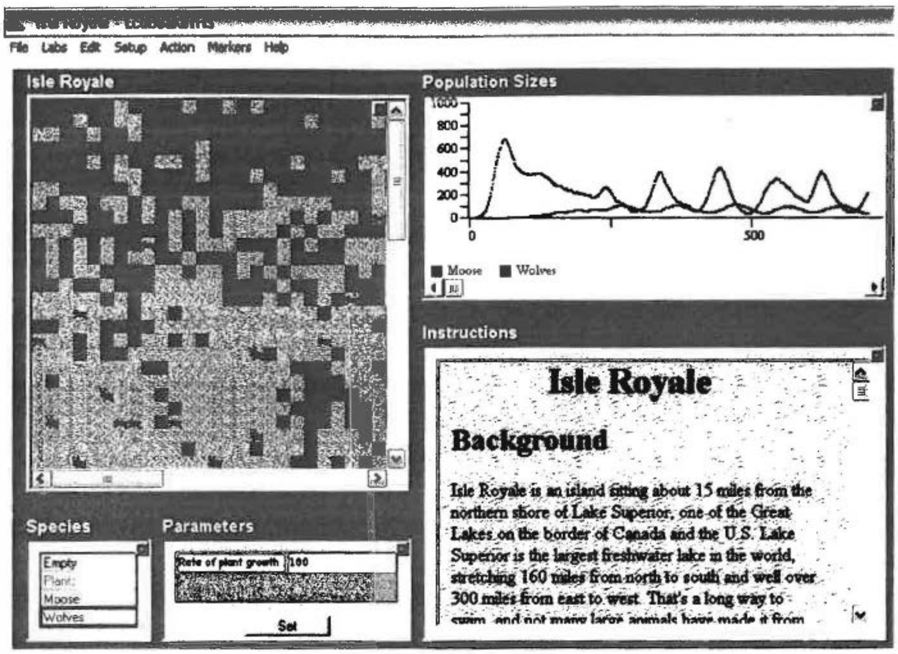

Figure 2. Screen shot of graphical interface displayed during the Isle Royale lab from EcoBeaker HS simulation software program.

Integration idea. While experience in the field is most desirable for science labs, oftentimes this luxury is not realistic due to money, time, safety or other constraints. In some cases educators have had to resort to paper labs for certain topics. Software simulations like EcoBeaker HS can provide students with hands-on experience with technology at the same time they are learning science. For instance, during a unit on population biology, EcoBeaker HS allows students to manipulate variables behind the predator-prey interactions between wolves and moose cohabitating on Isle Royale. This lab can be performed either before the population biology unit, as an introductory "what do you know?" activity or during the unit as a complementary activity to help solidify the topics being presented.

Case It!

Technology overview. Case It! is another example of computer simulation software but unlike EcoBeaker HS, this product, as part of a NSF-sponsored project, is available as a free download (for educational use) at http://caseit.uwrf.edu/caseit.html. Case It! software provides opportunities for advanced students (AP or introductory college biology classes) to "perform" common genetic lab procedures including Western blot, ELISA, and DNA electrophoresis. In addition to performing genetic simulations, the Case It! software also contains other components including the Case It! Launch Pad tool which allows users the ability to create Web posters (through a Web page editor) for posting their findings and an Internet conferencing system where users can present their results with one another via an online forum. Figure 3 shows a sample screen shot from the Case It! simulation software.

Integration idea. Although much more accessible than ever before, equipment for performing genetic procedures is still very expensive and oftentimes monetarily impractical in the public school setting. In yet another example of a situation where lack of funds and potential dangers to one's health pose as obstacles to performing actual procedures, the use of Case It! simulation software allows students the opportunity to participate virtually in complex genetic procedures, like DNA electrophoresis. (However one of the drawbacks to this software is its steep learning curve, especially for those who have never participated in the real procedure so teachers must be familiar with the software and able to provide step by step instructions for students.) One way to integrate the Case It! simulation software is to develop a collaborative case-based activity involving the genetics of inherited diseases. Another feature of the Case It! software is the Investigator, a tool that includes background information on a number of genetic diseases. Case It! simulation tools were used by Bergland et al. (2006) to develop a case-based project in which students took on roles as genetic counselors. Students had to research their chosen genetic disorder (which included breast cancer, sickle-cell anemia, and Huntington's disease, among others) and then "test" their patient's DNA for the presence or absence of specific genetic mutations. Then, using the Web page editing software students had to create posters that they would use to display their findings during a Web conferencing session. Volunteers posed as the patients during the Web conference and the students, as genetic counselors, had to discuss their results with them.

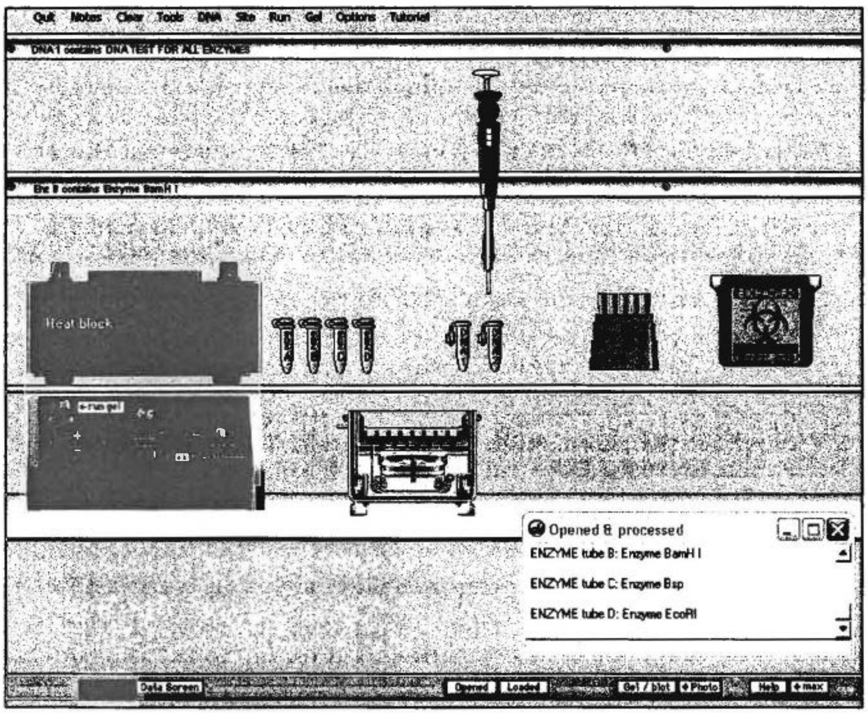

Figure 3. Screen shot of graphical interface from the Case It! simulation software program showing lab bench and associated equipment.

BioLab dissection simulations

Technology overview. Virtual dissections can provide students with great background information before performing actual dissections. BioLab (free demos available at http://www.biolabsoftware.com/) has created a number of dissection simulations available on CD-ROM, including frog, pig, cat, and fish. Each CD-ROM contains dissections with information for each associated organ, close-up photos and videos, and quizzes that students can take to monitor their understanding of the material. In addition to the dissection activities the CD-ROMs also include "minlabs" with variables that students can manipulate. The BioLab Frog CD-ROM, for example, contains a minilab that allows students to "test" and compare the affects of alcohol, cocaine, THC, and nicotine on the heart rate of a frog.

Integration idea. One way to integrate this technology into the classroom would be to introduce students to dissecting before performing the actual procedure. In one study by Akpan and Andre (2000), students who used BioLab's frog simulated dissection prior to the actual dissection (and students who only participated in the simulated dissection) were said to have learned significantly more anatomy than those who were not exposed to the simulation or those who experienced the simulation after the actual dissection.

Yet another use of BioLab dissection simulation technology would be to offer students extra credit for performing the virtual dissections. Especially when class time doesn't allow for more than one dissection per school year the virtual dissections allow students another opportunity to participate in hands-on activities while gaining content knowledge.

Nano Legends

Technology overview. CommGraphic Interactive's® Nano Legends is a computer video game designed to teach middle school-aged students about cells and cancer (the demo can be downloaded at http://www.nanolegends.com/index.html). Based on National Science Education Standards, Nano Legends is an adventure game in which students must maneuver Aerin, the main character, through a number of levels, the goal of which is to defeat the dreaded "Carcinogen Beast" and free the body of cancer (Figure 4). Integral concepts included as part of the element of play are investigation of cell structures, cellular respiration, and protein synthesis.

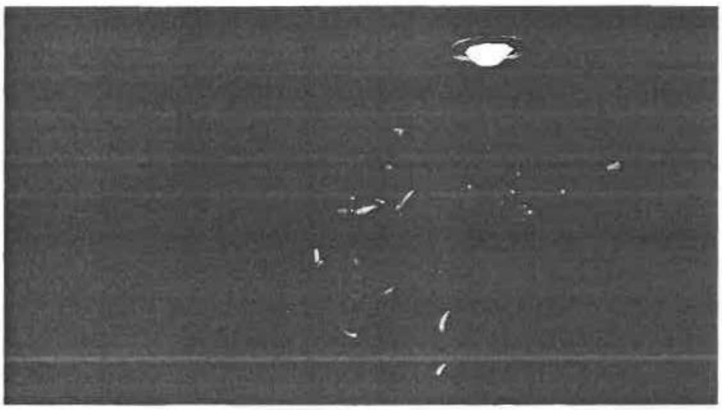

Figure 4. Aerin, the main character of the Nano Legends videogame, is shown in a screen shot taken during the first level of game play.

While students may be interested in playing video games in science class, one major obstacle to this technology may be its hefty pricing (1-pak for $119.95, 10-pak for $699.50, or 30-pak for $1,498.50). And although the instructions claim the game can be played with just a keyboard, maneuvering through the demo was extremely difficult. The other method of play is via a joystick, which may pose an unexpected added expense.

Integration idea. As not all students are avid gamers, requiring students to play Nano Legends does not seem like an ideal attempt at technology integration. Coupled with the high pricing, one idea would be to offer students the chance to earn extra credit by playing the game (and gain additional content knowledge by doing so). This solution helps cut down on costs (by reducing the amount of video game copies to be purchased) and puts students in charge of their own learning. It can also afford students an opportunity to partake in a collaborative effort by helping one another in an attempt to "slay the (Carcinogen) Beast".

Hardware technologies

Hardware technologies are physical components and are often associated with the machinery of desktop or laptop computers, i.e., monitors, modems, and printers. Hardware can also be used to describe other devices such as cell phones, liquid crystal display (LCD) projectors, and DVD players. In the science classroom, hardware may also refer to the plethora of lab devices like the microscope or centrifuge, arguably critical components to science education. This section on hardware will focus on newer technologies that have not necessarily been associated with use in the high school science classroom but offer unlimited potential for extending both students' content knowledge and experience with technology:

- Interactive whiteboards
- Handheld computers
- Audio and visual electronic devices
- Miscellaneous hardware

Interactive whiteboards

Technology overview. Many of the traditional instructional hardware technologies include overhead projectors, whiteboards, televisions with VCR or DVD players and, more recently, laptop computer monitors displayed with LCD projectors. One of the newest advances in K-12 instructional hardware technology is the interactive whiteboard. Essentially the interactive whiteboard is a touch-sensitive screen that connects to a desktop or laptop computer. Used in conjunction with a digital projector (commonly LCD), the interactive whiteboard allows the user to control the computer applications and perform other tasks directly from the projected image on the interactive whiteboard (see Figure 5). The use of the interactive whiteboard encourages movement around the room and teachers are not necessarily tied to their computers. This technology also enables the teacher to develop lessons around students using the tool, for instance, giving interactive presentations to the class.

One of the most well known interactive whiteboards is the SMART Board™ system from SMART™ Technologies Inc (http://smarttech.com/). Along with the ability to maneuver around the computer that it's connected to, SMART Technologies has developed a number of software applications to further enhance the opportunity for presentations and lessons. The main software application, SMART Notebook, is a free download that encompasses a variety of tools including a shade screen, which allows the teacher to reveal contents at his/her own pace much like revealing contents via overhead projectors (without the threat of the piece of paper covering the information falling off and exposing all the covered information in the middle of the presentation!). Yet another tool included with the SMART Notebook software is SMART Recorder, a screen recording tool that enables the user to record activities that are occurring on the computer, all of which can be narrated by the author. A number of educators have used the SMART Recorder to capture a lesson plan that they've dictated for a planned absence. The substitute teacher simply has to press play and the lesson unfolds for students to follow.

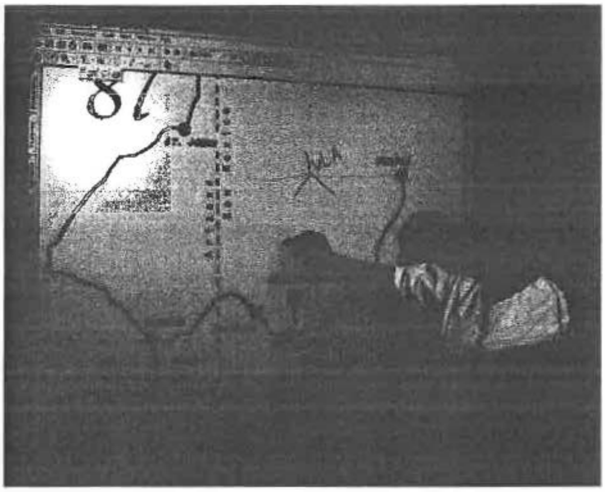

Figure 5. Photograph showing a teacher using an interactive whiteboard as part of a classroom lecture. Note the familiar menu and toolbars that can be accessed right from the whiteboard.

Integration idea. In addition to the recording of lessons for planned absences, another use of the interactive whiteboard technology is to combine all presentation ideas (Microsoft® PowerPoint® presentation, movies, Internet sites) into one location: projected on the whiteboard. Specifically with the SMART Board, the SMART Notebook software allows the input of PowerPoint presentation slides, photos, and movies. And because the software is available for free, teachers can develop lessons right from their home computers, and upload the lessons either from an email or from a portable storage devices like a CD or USB flash drive. Once in the classroom the instructor can access all their tools and information right from the whiteboard. With movies the teacher can start and stop the video on demand and make markings right on the whiteboard. Additionally, the interactive whiteboard can get students up and out of their seats, using the same features as the teacher.

Handheld computers

Technology overview. Computers have become increasingly faster, smaller, and more useful overall since their inception in the mid 1900s. With the ability to be easily transported, computers have surfaced in a number of previously inaccessible locations, like airports and subways. These PDAs have slowly been adapted from uses in the business world to uses in the classroom and a number of software applications suited to science education are available including graphing programs, data collection applications, and tools such as digital periodic tables and flashcards for studying. Portable handheld computers like Palm® OS devices (http://www.palm.com/us/) and pocket PCs (http://www.microsoft.com/) are becoming more user-friendly and are quickly finding a place in the science classroom. Because of their portability, handheld computers are getting students out of the classroom and into the field. Especially when used in conjunction with probeware (see *Miscellanous hardware*), handheld computers are proving to be an affordable piece of equipment that puts science inquiry and data collection in the hands of students, no matter where they might be (for instance, on the side of a stream bed or water reservoir).

Integration idea. In addition to their portability feature, handheld computers tend to be more affordable and easier to store than their bulkier counterparts (laptop or desktop computers). When used in conjunction with portable probeware devices, the possibilities for field observations and data collection can be endless. For example, in a unit on the circulatory system, there usually exists a lab that tests the affects of physical exertion on heart and breathing rates. During the lab students usually make inferences about how their bodies will respond to a series of jumping jacks or running in place. Then by palpating pulse rates and counting the number of breaths in a certain amount of time, students collect data that either support or refute their original hypotheses. A similar lab could be conducted (either in place of or in addition to the jumping jacks lab) in the field where a number of experiments could be devised – by the students. A handheld computer coupled with a heart rate sensor probe and a carbon dioxide gas sensor probe could be brought just about anywhere to test the affect of different activities on the cardiovascular system. By allowing the students to choose their own activities and make inferences it's getting the students to think not only about experimental design but also about science and how it relates to their own bodies. This allows them to take ownership of their data which many educators agree aids in content retention.

Audio and visual electronic devices

Technology overview. The terms audio and visual devices are used here to describe electronic hardware that can input or output (or, in some cases, both) audio or visual data in the form of sounds (music, lectures, etc.) and/or still or moving pictures (photographs, movies, etc.). In recent years, these devices have exploded in their popularity; there is rarely a school in the U.S. which has yet to be inundated with cell phones, MP3 players, and other arguably distracting pieces of hardware. Although generally viewed as annoyances these audio and visual devices have the potential to make great impacts in the classroom.

Integration idea. As there are a number of different audio and visual devices available, an integration idea will be provided in each of three categories: MP3 players, digital cameras and picture phones, and Web cameras (Webcams).

MP3 players. These devices are small electronic machines that store audio feeds, generally music, that function essentially as smaller and more versatile versions of portable cassette or CD players. Two examples of MP3 players include the hugely popular Apple® iPod® and Microsoft® Zune®. However, in addition to using these devices to store and play music files, another prevalent use of these devices is for the storage of files referred to as podcasts. Generally podcasts are newscasts, interviews, or other non-musical recordings. MP3 players, therefore, pose a unique opportunity for educators to reach their students. At the college level many professors are choosing to record lectures or other material and turn them into podcasts that their students can then download and listen to on their own. A similar tactic could be used in the secondary school setting, especially for students who don't seem to get the material the first time through. Teachers could make supplemental material available for those who wished to use them, for example, a study guide or review session (these data files can also be downloaded onto a computer and played with a free media player such as Windows® Media Player in the event that portable MP3 players are not available).

Digital cameras and picture phones. An important part of the science classroom experience is up close and personal interaction with a number of subjects. In a classification unit, for instance, students must imagine different species of organisms that are grouped into categories for a number of reasons. Prior to the discovery of DNA and the use of genetics for comparing relationships, categories were often created based on physical characteristics. One idea for a lab or introductory activity would be to ask students to work in groups to build their own classification system (or create a dichotomous key) by using digital cameras or picture phones (cell phones with abilities to capture photographs or videos) to take images of their objects.

Web cameras (Webcams). Web cameras are apparatus that can be connected to computers and have many different uses. In addition to taking both still and moving pictures, Webcams are used to connect people all over the world in live, face to face conversations. Global collaboration is an up and coming way to connect students worldwide and Webcams provide a unique avenue for facilitating those connections. Not only can students talk to one another but with a high speed Internet connection and a Webcam, students can see their counterparts, whether simply across the state or across the ocean.

Miscellaneous hardware

There is an endless amount of hardware devices found throughout the modern world. This section, however, will focus on describing two hardware devices that have large potential for integration into the science classroom, with an example given for each device.

Portable probeware devices. Data collection can be a large component of science lab sessions, taking valuable time out of the class period. Advances in modern technology have lead to the manufacturing of portable and affordable, probeware devices. Developed for use with a variety of hardware such as laptops, handheld devices, and some graphing calculators, probes are fast becoming staples of the secondary science classroom experience. Their portability enables teachers and students to collect "real" data, information gathered from the field (and not simulated situations within the classroom walls). Oftentimes accompanying software allows users to collect and plot data instantaneously, affording teachers and students more class time for presentation of information and discussions. In a lab example mentioned previously, probes can permit students studying the cardiovascular system the opportunity to perform a number of experiments instead of simply recording and plotting the affects of jumping jacks. With the number of data collection instances in science labs, the occasions to utlize probeware devices are many and their uses, endless.

Microscope cameras. A science classroom without a microscope is like a rainforest without rain. However, due to the unique skill (and luck) of navigating the microscopic world, not all students will easily see the amoeba engaging in phagocytosis; for those who can view it, it's quite a marvel but those who aren't fortunate enough to have "hungry" amoebas miss out. With the use of a microscope camera and projector, a roomful of students can view the action taking place under a single microscope, a large, real-time image in surprising detail. Additionally, microscope cameras afford teachers the opportunity to use images of actual organisms (for example, onion root tips) when describing the oft-confusing stages of mitosis or meiosis.

Chapter Four: Conclusions and Recommendations

The movement of technology integration into the science curriculum is not a novel event. Standards have been in place for over ten years that detail the technological skills that 21st century teachers should be able to demonstrate (Dexter, Doering, & Riedel, 2006). And with the documented advantages of technology in the classroom (ease of data collection, motivation, collaboration, self-efficacy, and academic achievement), the demands for integration will continue.

A teacher's preparation and training directly influences his/her conception of technology use in the science classroom (NCES, 2000). Yet, the typical student's tenure in a contemporary preservice educational program does not routinely involve in-depth experience with appropriate technology integration (Angeli, 2005; Gado et al., 2006; Okojie & Olinzock, 2006; Watson, 2006). If experience with technology does exist in the teacher education program, it is commonly in the form of a standalone class, which can make technology appear as a separate, superficial entity (Flick & Bell, 2000; Okojie & Olinzock, 2006).

The goal of this paper is to present some of the more accessible forms of technology to assist both preservice and in-service teachers with devising methods of integration (see Figure 6 for a summary of the technologies). Although, as can be seen from the information presented in chapter three, technology integration can be straightforward, teachers still need introduction to and experience with its implementation. It is suggested that teacher preparation programs spend a fair amount of time analyzing their current curriculums for ways to incorporate more opportunities for preservice teachers to gain exposure to modern technologies. In order for teachers to understand the appropriate pedagogy of technology integration in the science classroom, technology must be infused *throughout* the education program (Angeli, 2005; Flick & Bell, 2000; Henriques, 2002). Preservice teachers (as well as in-service teachers) must be taught to acknowledge the difference between merely having technology in the classroom and utilizing technology as a *resource* to enhance the environment and facilitate the learning process and experience for students. Some suggestions for teacher education programs to achieve this goal include:

- Incorporating technology requirements into standard education classes, including methods courses;
- Developing technology-specific mini "how-to classes" that cover topics such as Web site development and how to create podcasts;
- Creating courses that involve both the introduction to and the use of handheld computers and probeware; encourage education students to use these technologies to devise inquiry-based labs or activities.

In-service science teachers who do not have adequate exposure with technology must be willing to acknowledge their inexperience by committing time and effort to updating their skills. Participation in numerous professional development opportunities is a great way to gain exposure to technology; these include:

- Attending workshops and conferences which highlight the use of technology in the classroom;
- Reading of relevant literature (journals, periodicals, etc.);

- Partaking in local collaborative efforts by sharing knowledge among peers;
- Registering for classes at a local college or university;
- Volunteering for research projects that utilize new technologies and procedures;
- Investigating grant opportunities that will provide not only funding to add new technology to science classrooms but also the training to use it.

In order for teachers to be successful in their professional development endeavors, they must be supported in both time allotment and funding by administrators and policymakers (Clark, 2006; Glenn, 1997; NCES, 2000). School administrations should strongly consider frequent professional development opportunities that give in-service teachers the experience they need to become more efficient with technology integration. Suggestions for school administrators include:

- Offering bonuses to teachers who can demonstrate technological abilities above and beyond the basic skills;
- Providing stipends for teachers to attend conferences and workshops (perhaps larger stipends for teachers who are presenting at these events);
- Hosting training events on the current technologies. Many of the companies that produce technologies for the classroom offer training on their products at little or no cost; schools should take advantage of this benefit.

Internet-Based Technologies
Web site evaluation
Web sites as instructional resources
Web sites as content resources
WebQuests
Email and global communication
Software Technologies
Web editing/development software
EcoBeaker HS
Case It!
BioLab dissection simulations
Nano Legends
Hardware Technologies
Interactive whiteboards
Handheld computers
Audio and visual electronic devices (MP3 players, digital cameras and picture phones, and Web cameras)
Miscellaneous hardware (portable probeware devices and microscope cameras)

Figure 6. Matrix summarizing the Internet-based, software, and hardware technologies presented in chapter three.

Exposing teachers to and familiarizing them with the available technologies will hopefully allow them to see the advantages of its use, and in meaningful ways. One positive outcome of the introduction and interaction with technology is a change in teachers' attitudes and beliefs about their existing pedagogies, which has been shown to be a substantial deterrent at attempts to incorporate technology into the classroom.

Another benefit that exposure to technology can provide is empowerment for teachers to take initiatives to think outside the box with technology integration. The more teachers use and become familiar with technology, the less likely they will need assistance for minor technological issues. By reducing the number of calls for technical assistance, this can free up time for technology support staff to attend to other concerns, a scenario many schools would embrace.

The global market and workplace today demand knowledge and skills associated with technology. More often than not the responsibility to provide students with the exposure to technology is left up to the classroom teachers, whether or not the teachers themselves are experienced with it. The more teachers know about technology, the more likely they are to utilize and integrate it. In short, if teachers are not practiced in using technology or, perhaps more importantly, trained in how to properly integrate it in their classrooms, they will not use it - a trickledown effect that will have negative impacts on our students now and in the years to come.

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Appendix A. Sample Web site evaluation adapted from http://www.cyberbee.com/

Site Title: ______________________________ Subject: ______________

URL: ____

To determine the worth of the Web site you are considering, evaluation its content according to the criteria described below. Circle "Y" for yes, "N" for no, and "NA" for not applicable.

1. First Impression			
A. I am able to quickly determine the basic content and purpose of the site.	Y	N	NA
B. I am able to determine the intended audience of the site.	Y	N	NA
2. Authority			
A. The author(s) of the material on the site is clearly identified.	Y	N	NA
B. Information about the author(s) is available.	Y	N	NA
C. According to the information given, author(s) appears qualified to present content found on the site.	Y	N	NA
D. The sponsor of the site is clearly identified.	Y	N	NA
E. A contact person or address is available so I can ask questions or verify information.	Y	N	NA
3. Information Currency			
A. Latest revision date is provided. Date:	Y	N	NA
B. Content is updated frequently.	Y	N	NA
C. Links to other sites are current and working properly.	Y	N	NA
4. Information Quality			
A. The purpose of this site is clear: ☐ business/commercial ☐ news ☐ entertainment ☐ informational ☐ government ☐ personal	Y	N	NA
B. The content achieves this intended purpose effectively.	Y	N	NA
C. The content appears complete (no "under construction" signs, etc.).	Y	N	NA
D. The content of this site is well organized and easy to navigate.	Y	N	NA
E. The information in this site is easy for me to understand.	Y	N	NA
F. This site offers sufficient information related to my needs/purposes.	Y	N	NA
G. The content is free of bias, or the bias can be easily detected.	Y	N	NA
H. The information appears to be accurate based on my previous knowledge of the subject.	Y	N	NA
I. The information is consistent with similar information in other sources.	Y	N	NA
J. Grammar and spelling are correct.	Y	N	NA
5. Further Information			
A. There are links to other sites that are related to my needs/purposes.	Y	N	NA
B. The content of linked sites is worthwhile and appropriate to my needs/purposes.	Y	N	NA

Based on my overall observations, I rate the content of this site as:
☐ Very useful for my needs ☐ May be useful for my needs ☐ Not work coming back to

Comments:

Appendix B. Web sites as instructional resources

Resource	Web Address	Highlights
4 Teachers	http://www.4teachers.org/	A comprehensive site with a host of online tools that aid teachers with integrating technology into the classroom.
Access Excellence	http://www.accessexcellence.org/	Web site created by the National Health Museum which includes links to many interesting sites, including x-ray images of human bones and Biology Education Online, a free online resource (peer reviewed journal) provided by NSF.
Action Bioscience	http://www.actionbioscience.org/index.html	An education resource of the American Institute of Biological Sciences that provides access to a number of peer reviewed lesson plans and activities.
Education World	http://www.educationworld.com/	An all-inclusive resource that provides lesson plan examples, professional development ideas, and classroom management suggestions. This site also includes a technology integration section with detailed explanations for novice users.
Global Schoolhouse	http://www.globalschoolnet.org/index.html	Global collaborative efforts enable participants worldwide to "meet" virtually to interact and communicate to plan meaningful project-based learning opportunities.
National Association of Biology Teachers	http://www.nabt.org/	A Web site full of resources for biology teachers, including links to instructional materials and funding opportunities.
School Notes	http://www.schoolnotes.com/	A school-to-home communication platform for teachers, students, and parents; great for posting homework and other information. Registration only required by the teacher.
United Streaming	http://www.unitedstreaming.com/	A fee is required however this is an excellent resource for finding high quality videos for numerous science-related topics.

Appendix C. Web sites as content resources

Resource	Web Address	Contents
DNAi	http://www.dnai.org/index.htm	Timeline and discovery of genetics and DNA. Lesson plans and activities included.
Exploratorium's Cow Eye Dissection	http://www.exploratorium.edu/learning_studio/cow_eye/	Still and live images of a cow eye dissection. Use as an introduction to cow eye dissection or for students who have religious or moral dilemmas with animal dissections.
Cells Alive!	http://www.cellsalive.com/	A comprehensive introductory cell and microbiology Web site. A CD can also be purchased that includes all photographs and videos found on the site.
Learn.Genetics	http://learn.genetics.utah.edu/	Highlights of this site on genetics include a virtual DNA extraction lab and instructions on how to perform actual DNA extractions with household chemicals (safe and easy).
Science a Go Go	http://www.scienceagogo.com/index.shtml	A science news Web site that is presented in a fun and readable manner (common words and no "scientific jargon"). When reading science is fun and informative, students may be more apt to indulge.
Digital Learning Center for Microbial Ecology	http://commtechlab.msu.edu/sites/dlc-me/	This Web site contains lots of interesting information about select microbes. Cartoons can make it more attractive to students.
Online Biology Book	http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html	Just as the title implies, this is essentially an online biology textbook. The site was created and is maintained by Estrella Mountain Community College; many of the chapters are updated regularly.
Animal Diversity Web	http://animaldiversity.ummz.umich.edu/site/index.html	A user-friendly Web site with animal-related facts, pictures, and even sounds!