2005

Using web-based material to support secondary science curriculum

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Abstract
Web-based materials have introduced a new way of supporting students' learning and teachers' knowledge of the secondary science curriculum. However it is difficult to know which materials to use and how to use them. This review discussed some of the methods for teaching science, web-based materials that support these methods, how the Internet can add to teachers' knowledge, and some negative effects of using this technology. This review shows how teachers can integrate web-based materials into their teaching strategies, and can help teachers who have integrated them to be aware of the negatives of using the Internet in the classroom. Resources include published articles, personal interviews, science education websites, and recognized published books.

Using Web-Based Material to Support Secondary Science Curriculum

A Graduate Review

Submitted to the

Division of Instructional Technology

Department of Curriculum and Instruction

In Partial Fulfillment

Of the Requirements for the Degree

Master of Arts

UNIVERSITY OF NORTHERN IOWA

by

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May, 2005

This Research Paper by: Ghadeer Filimban

Titled: Using Web-Based Material to Support Secondary Science Curriculum

has been approved as meeting the research requirement for the

Degree of Master of Arts

4/21/05
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INTRODUCTION

Web-based materials can enhance students' learning and teachers' knowledge of the secondary science curriculum. This review assesses the difficulties in determining appropriate teaching strategies for real-life science applications structured around the use of web-based materials. This study also describes the Internet as a support system, not a substitute for real-life interaction, and how it can be used as such. It explores the problems of implementing new technologies into the curriculum. Studies such as this one are important in emphasizing the benefits of technology in the classroom, and for helping teachers find relevant and organized information. The scope of this study combines teaching techniques and technological information in order to support teaching science in the classroom.

This study contains a plethora of resource materials that support the idea of using the Internet in a secondary science classroom and curriculum. There are many available methods for teaching science and a variety of Web sources that supplement secondary education. In fact, there are so many Web sources available that teachers of secondary science have trouble choosing appropriate materials to use in their classrooms and ones which fit their needs. This review addresses how educators can incorporate technology into their science curriculum using various teaching strategies to guide the selection of suitable materials.

Various effective teaching strategies for the secondary science curriculum can be supported by websites containing applications useful in real-life situations. When teachers combine these elements, it can be beneficial for both the teaching and learning of science. Teachers need to be knowledgeable about the Internet and the field of technology in order to introduce new teaching methods into their secondary science curriculum using web-based materials. However, they should not solely rely on the Internet, but also use traditional teaching methods for science and integrate these methods with using the Internet. This study describes effective methods for teaching science, provides helpful websites that apply the methods and technology in real life, demonstrates how teachers can use these websites to support various teaching strategies, shows how the Internet can supplement teachers' knowledge in his or her specific area, and discusses some negative effects of using the Internet in secondary science education.

METHODOLOGY

It was necessary to have reliable and valid resources in order for the researcher to obtain results that were consistent and repeatable. Several electronic search-engine resources were used for keyword-searches by subject or title. The researcher used ERIC (SilverPlatter), Expanded Academic ASAP (InfoTrac), and Education Full Text (WilsonWeb) databases to supply this information. The key terms used in order to find this information from the search engines were: "Internet and teaching," "integrating technology in classrooms," "negatives of the Internet," "benefits of Internet for teachers," "Internet and secondary science education," "teaching science using technology," "scientific websites for students," and "enhancing teaching with technology." The main criteria for validity in this study was to use only refereed journal publications, organization-based research (not individual), and current Internet sources.

The information from these databases related to education and came from highly reputable individuals associated with universities and well-known professional research projects, which made the ensuing results more reliable and the search itself more efficient. The researcher also used World Wide Web search engines such as MSN Search, Yahoo!, and Google to find websites that teachers can use in the secondary science classroom. The same descriptors were used.

Another research method involved interviewing educators who had experience in teaching either technology or science education at the University of Northern Iowa. The two educators who were willing to do interviews were Dr. Greg Stefanich and Mr. Aaron Spurr; both have accumulated information from their own personal teaching experience. The researcher conducted two interviews with instructors who are professors from the University of Northern Iowa: one with Dr. Greg Stefanich, and the other with Mr. Aaron Spurr. Dr. Stefanich is a professor of curriculum and instruction and Mr. Spurr is a secondary science instructor who uses current technology in his teaching at Price Laboratory School in Cedar Falls, Iowa, which is affiliated with the University of Northern Iowa. Dr. Stefanich, who was the Interim Department Head of Curriculum and Instruction, (personal communication, February 10, 2004) provided his experience with teaching science in inclusive classrooms. Mr. Spurr (personal communication, February 13, 2004) introduced the researcher to many different websites that apply teaching science to real-life situations. Their knowledge was gained over time and through interaction with many students; giving them a balanced perspective. The researcher used these professors' thoughts, knowledge, ideas, and experience as living examples of how teachers utilize technology to enhance teaching the sciences.

The researcher found a variety of sources, including published articles, recognized published books, and personal interviews, that provided teaching strategies and methods. Also, all of the information included was relevant, but not all was directly meant for this area of study. For example, the resources discuss how the Internet supports teaching at different levels and in different subjects, but did not specifically focus on how they support the teaching of science at the secondary level.

The researcher analyzed these sources by locating teaching strategies in articles, finding websites that discussed useful, real-life applications, and describing how each one could enhance or detract from the teachers' knowledge of instructional models specifically for use in secondary science education. The researcher evaluated the quality of the information by judging the sources from many different standpoints. One of these criteria was that sources come from valid and reliable authors and studies; the authors needed to be experienced and highly qualified. Another aspect of evaluation was the need for information associated with the subject of study to be up-to-date. When the discussion turned to the actual Internet and technology, the sources had to be current which is defined as within the last five years, given the rapid rate at which on-line sites change. However, when teaching theories and pedagogy were found and utilized, older books were still useful because those ideas would have been slower to change. In addition, this research was supported by the ideas and individual theories of experts who had published work that was relevant to the focus of this study.

ANALYSIS AND DISCUSSION

A wide variety of methods and strategies have been used throughout the years in teaching science. This study will discuss teaching strategies including Bodzin's inquiry learning (Bodzin & Cates, 1996), Engelmann's direct instruction (Stefanich, 2001), Chiappetta's science projects (Collette & Chiappetta, 1989), Collins's hypothesis-based learning (2004), Stahl's cooperative learning (1996), Trowbridge and Bybee's demonstration and laboratory work (1996), Collette and Chiappetta's recitation method (1994), and Harlen's discovery learning (1992). These were the most common strategies that science teachers have used in classrooms and are relatively current methods. Their instructional strategies included the ARCS (attention, relevance, confidence, and satisfaction) model of John Keller (Dick, Carey, & Carey, 2005). Teachers need to be aware of how to apply these strategies to science education websites. The purpose of this study was to explore how teaching strategies in science could be applied when teaching with web-based materials. Understanding these strategies was vital for recognizing how they can best be applied to the web format.

Effective Methods or Strategies for Teaching Science

Science education has taken a variety of directions over the years. It has changed "from the early days of school science in the nineteenth century through to the Nuffield projects of the 1960s and the more recent Schools Council project in integrated science (SCISP)" (Levinson, 1994, p. 22). These earlier movements asked the questions: "What is appropriate for 'school science'?" and "Who decides what methods are adequate?" (Levinson, 1994). These strategies have helped teachers prepare their lessons in order to involve students in activities that interest them. The methods that have been used for teaching science include: Bodzin's inquiry learning (1996), Engelmann's direct instruction (1968), Chiappetta's science projects (1989), Collins's hypothesis-based learning (2004), Stahl's Cooperative learning (1996), Trowbridge and Bybee's demonstration and laboratory work (1996), Collette and Chiappette's recitation method (1989), and Harlen's discovery learning (1992). These methods provide a variety of techniques that help students ask questions, solve problems, and discover new information for themselves (Stefanich, et al., 2001).

Inquiry Learning

According to the National Science Education Standards (1996), inquiry learning is "the diverse way in which scientists study the natural world and propose explanations based on evidence derived from their work" (p. 1). It is a way of thinking and a method of teaching that begins with designing a question or hypothesis to be investigated in the students' work, and concludes with having the students use their own intellect to solve the problem (Bodzin & Mitchell, 1996). The reason for using inquiry learning in a classroom stems from the concept of scientific literacy: "scientific literacy is commonly portrayed as the ability to make informed decisions on science and technology-based issues and is linked to deep understandings of scientific concepts, the processes of scientific inquiry, and the nature of science" (Bell, Blair, Crawford, & Lederman, 2003). By teaching the method for acquiring the facts and resources necessary to develop a successful experiment, teachers give their students the capability to reproduce a multiplicity of experiments following the scientific method applicable to any study, so long as they have the tools. It also requires students to act autonomously giving them an appreciation for how science is conducted in a realistic setting, and also giving them the freedom to peruse a wide range of interests (Stoddart, Abrams, Gasper, & Canaday, 2000).

The procedures for the inquiry learning method are as follows: the instructor presents an invitation to learn, then they prepare the students through providing them with the appropriate background knowledge and skills needed to solve a problem, next they present the phenomena and let the students gain information by asking questions as the teacher responds directly with an affirmative or negative answer, and finally the students are asked to introduce theories or reasons for the event without teacher intervention. None of the students' conclusions are based on the teacher's opinion of the matter, and the teacher promotes problem-solving skills and methods by being an available and attentive listener (Stefanich, et al., 2001). This method was developed as a student-based, hands-on technique. It was designed to engage and familiarize the students with their own learning process. It gave learners a certain amount of responsibility and freedom in choosing what they would learn as well.

With this process, students must also engage in a higher level of thinking and understanding. This is because students "reflect on their own investigative processes and experiences" (Carlson, Humphrey, & Reinhardt, 2003, p. 10). According to Carlson, Humphrey, & Reinhardt, it is an important method because it integrates the scientific method into the thought processes in other areas. For this method to be successful, it requires that teachers continuously assess the students' progress. Feedback is given in all steps of the project to help students make sure they are doing science as it should be done. In the end, evaluation exams are assessed not only to determine the students' progress but to provide teachers with an idea of whether to continue improving their instructions or to modify them.

Direct Instruction

Direct instruction is "a strategy intended to improve learning by getting students to focus on thinking to understand rather than just thinking for knowledge" (Stefanich, et al., 2001, p. 71). This learning process emphasizes hierarchical learning with simple tasks on the bottom layer, then working up to more complex problems and solutions. Students are to apply what they've learned in previous levels to solve new problems. This method promotes logical ordering of knowledge, facilitates memory retention, and helps to alleviate contradictions or inconsistencies in scientific knowledge. Every direct learning opportunity has a structure focused on a specific outcome. With this method, "knowledge and instruction should build on students' experiences, rather than be viewed as fixed or determined" (Smerdon, Burkam, & Lee, 1999). Information becomes more meaningful to the students and engages them, if what they are studying affects them in a personal way. Direct instruction allows students the opportunity to explore their own questions.

The procedures for this method are to: create a hypothesis, determine goals, categorize the goals, describe the goals in context, find problems that students can solve and see the results, create measurement techniques for the problem, collect information to use, analyze the information, and then compare the findings with the hypotheses (Stefanich, et al., 2001). Behaviorism is one philosophy used to describe the theory of direct instruction, because knowledge is being passed between the teacher and the students by means of facts, concepts, and definitions. Moreover, "...knowledge is constructed by learners as they attempt to make sense of their experiences" (Driscoll, 2000, p. 376) which is the premise of constructivism. Constructivism involves learners creating associations to construct order and predictability with the information given (Trowbridge & Bybee, 1996). The end result of direct instruction is "a rigorously developed, highly scripted method for teaching that is fast-paced and provides constant interaction between students and the teacher" (Lindsay, 2002, p. 1).

Problem-Based Learning

Problem-based learning places students in a position where they have to create environments and criteria to work on independently or in small groups, with teacher supervision, to delve into their own discoveries and engage the students into a community of learners (Barr & Tagg, 1995). It is a flexible learning style meant for continued use. "...to be successful in their chosen career, students need practice solving ill-structured problems that reflect life beyond the classroom. This skill is the goal of problem-based learning" (Jones, 1996). The structure for this strategy is based on three styles of constructivist and social theories of learning. This strategy's first feature is to be interactive, where the students are physically involved with the research and experimentation. The second feature involves students interacting with learning through actions, discussions, and collaborations. Finally, problem-based learning is conducted through a situated design, in which students are the ones who collaboratively establish their own objectives and projects (Polman, 2000). The procedures for this method are: teachers provide guidelines and examples for the project and students then select a topic or idea to begin the planning steps. After that, teachers supervise the project during school time to answer questions or provide assistance, and finally teachers assess students' learning based on the results of the project (Chiappetta & Collette, 1989).

Hypothesis-Based Learning

Hypothesis-based learning provides hands-on training for students, and requires critical thinking based on stating a hypothesis (National Science Teachers Association, 2004). It is commonly accepted that there are two aspects to the scientific method, referred to as "hypothesis formation" and "experimental design" (Klahr & Dunbar, 1988). The first builds the theory, and the second confirms it. Hypothesis-based learning focuses on the formation side of the experimental process. The procedure for this is to: link prior knowledge to a hands-on experience, form a hypothesis, and then test the hypothesis by using scientific method and experimentation. Researchers have found that conducting experiments in this manner is "more productive in achieving current standards for scientific literacy than continuing to refine ideas and techniques based on the coverage of conceptual content" (O'Neill & Polman, 2004). With the help of teachers, students reflect on their findings and share what they have learned with each other. The benefit of using this strategy is that it helps engage the students' higher thinking levels. The teacher challenges the students to try to prove their thoughts and ideas about phenomena they experience so the students experiment with a variety of sources that are related to their topic of study.

Cooperative Learning

Cooperative learning in science classrooms (Stahl, 1996) demonstrates how working in a group enhances individuals' learning abilities. This type of teaching strategy, according to Robert Stahl, focuses on maximizing each student's academic learning so that, days and weeks after the group no longer meets, each student can demonstrate the same knowledge and abilities that were used during the group activities. He says, "Each student can then achieve his or her learning goal if and only if the other group members achieve theirs" (Deutsch, 1962). This teaching strategy considers many aspects of the learning process. To start with, the instructor must set clear and specific learning outcomes for students. With these objectives laid out, students focus on what they need to learn rather than merely on what they need to do to complete the task.

Secondly, the group needs to 'buy into' or accept the group's objectives. It is important for the groups to come up with their own objectives because it engages them in their own learning process. This way each individual accepts their gained knowledge as their own construct and not as dictated information; it gains the group's knowledge as well. The third idea that instructors are to consider, according to this strategy, is providing instruction for what the group does and how students can display their new knowledge to the instructor and the rest of the class. This step is completed by giving out sheets of paper with instructions on them before the students engage in their groups. The next idea to consider is how the teachers choose these groups. According to Stahl (1996), heterogeneous groupings are sufficient and most beneficial. First, the instructor mixes up students according to academic level. Other factors include ethnic background, race, and gender. However, the most important factor for this grouping to work is compatible academic levels (Stahl, 1996).

Another important idea focuses on positive interdependence within the group. The instructor controls this by stressing that students know they are responsible for making sure that all members of their assigned group complete their designated tasks. Positive social interaction is also important in completing a task for the group. Putting individuals with different learning styles together does not automatically mean that they will work together positively. Therefore, the instructor takes the initiative to be the leader and lets the students recognize appropriate ways to interact within the group. Another factor taken into consideration is time. It is imperative to give enough time to the group so they can complete the task, but too much time will often result in apathy and loss of attention. Individual accountability makes students more responsible for their own learning. Instructors test students before and after the task to see if there is any increase in knowledge (Stahl, 1996).

Research into this method of teaching has revealed it to have some of the most diverse, wide-ranging benefits of almost any method of learning. The outcomes in achievement have shown students to demonstrate:

> ...continuing motivation, social and cognitive development, moral reasoning, perspective-taking, interpersonal attraction, social support, friendships, reduction of

> stereotypes and prejudice, valuing differences, psychological health, self-esteem, social competencies, internalization of values, the quality of the learning environment, and many other outcomes. (Johnson, Johnson, & Stanne, 2000, p. 1)

The outcomes above are just some of the many that students have demonstrated using this style of learning.

Demonstration and Laboratory Work

According to Trowbridge and Bybee, laboratory work is "the process of showing something to another person or group" (1996, p. 185). This method of teaching is a specialized form, particularly meant for use when a specific concept is to be conveyed. It is important to note that research has shown that the method is most effective when the purpose of the exercise is apparent.

There are many steps in planning a successful, well-organized demonstration. One of these steps identifies the main instructional goals the teacher desires to achieve. Next, if the instructional goal is difficult, the teacher demonstrates the goals in chunking fashion, which is "the action of grouping information" (Lohr, 2003, p. 201). Third, the teacher chooses the appropriate activities to show these objectives. After that, the teacher designs the activities and students participate with collaboration. Fifth, the teacher gathers and prepares the important materials, tools, and visual aids to teach the lesson. Subsequently, the instructor practices the lesson before teaching it to the class. Seventh, the teacher outlines questions throughout the lecture. In the last step, the educator considers evaluation techniques. These techniques include written and verbal techniques. Written techniques involve student's completion of a written summary of the demonstration. Upon completion of the summary, students are requested to take a quiz or prepare diagrams to show their understanding of the demonstration. These verbal techniques include asking questions during the demonstration to help students learn and hold their attention (Trowbridge & Bybee, 1996).

The Recitation Method

The recitation method is based more on memorization than inquiry. Larry M. Ludwig describes it as one of the best ways to improve memory retention because it involves active participation from the student and moves information from the short-term memory to long-term memory (as cited in Jackson, 2004). According to Collette and Chiappetta (1994):

> The Recitation method is characterized as a question and answer session during which the teacher asks a series of questions and the students provide the answers based on what they have read in their textbook or other assignments or what has been presented by the teacher during a lecture, demonstration, or other activity. (p. 150)

With this method, the teacher evaluates whether or not students have learned what was introduced from the textbook or lecture. The purpose of this method is to develop the understanding of ideas and concepts and be able to explain different terms. This does not mean that students repeat information verbatim (Singh, n.d.). They must understand the concept and then restate it in their own words, with their own examples. According to Hashmi (n.d.), recitation is an active form of learning where students must participate in the process of memory retention. There are many unique issues that teachers consider during the recitation process. First of all, the teacher introduces the reason behind using this method for the learners, so that students understand that they do not need to be worried during the teacher's assessment. The teacher also uses the students' feedback during the recitation method for his or her base of clarification or explanation of these ideas. However, this assessment helps teachers understand where the students' knowledge stands and enables the teachers to improve their teaching techniques over time. Eventually, students recognize the advantage of using this method in their learning experience (Collette & Chiappetta, 1994).

Discovery Learning

Discovery learning "is the successful result of building and testing conceptualizations of the phenomenal world through empirical inquiry" (Zachos, Hick, Doane, & Sargent, 2000, p. 1). Students build and test concepts, following in scientists' footsteps. Before this strategy, students gained information solely through the teacher and their lectures. With the discovery learning strategy, students are able to take the information from their teacher and apply it to hands-on experiments. Students investigate new relationships and then apply that new knowledge to everyday life (Harlen, 1992). Research has demonstrated that students are able to develop even complex concepts, such as density through the discovery learning method. One of the benefits for teachers using this method is that the concepts and testing can be completed and studied in a relatively short period of time (Zachos, 2000).

Students, on their own, are usually unable to discover what the teacher wants. Therefore, the students need to be guided in their personal discovery. According to Dr. Greg Stefanich, discovery learning follows different approaches which include explanation, concepts, application and evaluation (Stefanich, et al., 2001). The first approach, explanation, involves interactions where students explore materials with each other. The teacher directs the second approach, concepts, to focus on the important vocabulary, and relates this to the teaching strategy. The application aspect of this approach occurs when students apply new knowledge to various situations in life. Finally, the evaluation approach examines students' outcomes of the experiment.

Websites that Support Science Teaching Methods

Websites are designed to meet various goals. These goals often coincide with those of the teachers, because they are useful in the classroom and could easily be integrated into an instruction plan. Moreover, these websites also offer a variety of options to meet the needs of diverse learners. There are many types of web-based materials that teachers can use to support their teaching strategies. The researcher analyzed four types of web-based materials including inquiry-based learning, simulations, real-time data, and problem-based learning.

Inquiry-Based Learning

Inquiry-based learning websites support learning through focusing on improving the student's ability to solve new problems and answer challenging questions. These web-based materials support the inquiry learning method for teaching science by helping students to define and solve problems. Chatham High School's ninth-grade earth science students used an inquiry-based weather lesson that compared web-based material with the local climate (Holzer, 2004). The results showed that:

> The inquiry-based weather lesson conducted at Chatham High School had a significant impact on the effectiveness of the students to learn science. The combined use of inquiry-based instruction, automated data loggers and online data is one methodology that can be employed in more classrooms to ensure that students are going to learn how to apply the thought processes inherent to the sciences. (p. 1)

These sites also include support from teachers or organizations, and various communication channels such as chat and message boards for long distance learning. This allows students to find answers to their questions when they are away from school. According to Moore and Huber, "Interactive Internet resources provide effective means for teaching inquiry-based science at the upper-elementary through introductory college levels" (2001, p. 1).

Teachers can find various units, tools, and activities to apply the inquiry-based learning method. Moreover, teachers can use inquiry-based learning websites to determine which questions can be asked and discover ways to help their students reach answers. Students and teachers alike can find background information and current events related to the phenomenon, and the systems allow for collaboration with other communities. In addition, these websites support the direct instruction method by providing teachers with an effective structure for their lessons. Students can determine the outcomes and define the results using the instructional delivery, which directs their learning and allows them to know what is expected of them (Stefanich, et al., 2001).

Furthermore, the teacher can divide the class into small groups to do the activities by following website guidelines that contain various example activities for curriculum. During these activities, the teacher assists the students and provides the learners with the means to find the answers to the problem, which applies the problem-based learning method. Moreover, the students are encouraged to think deeply in order to solve their problem, which applies the hypothesis-based learning method. In addition, inquiry-based learning utilizes the cooperative learning method in that students are required to focus on the knowledge they've learned instead of following assigned steps. The students must work together on a project which is highly structured by the teacher in order to arrive at a specific conclusion using only what they've learned in their lessons. Similar to this method is the demonstration and laboratory work method, in which the students first view their teacher demonstrating the steps of the project before doing the project. This way, the students have the opportunity to ask their teacher about why the project is conducted in a certain way. Students are involved in discussions before they do the project themselves which clarifies the process.

Inquiry-based learning websites help teachers provide feedback to the students about mastery of the learned material and which areas they need to focus on through the recitation method. This also motivates the students when they recite what they are learning in their own words and realize how well they have retained the information. In addition, teachers will ask complex questions of the students to make them think at a higher level and involve the whole class in the interaction in order to solve the problem. Finally, discovery learning places students in the position of a scientist where the students must take responsibility and complete science experiments on their own. The websites provide them with ideas for research topics, examples for how to conduct an experiment, and raw data and information. Several examples of inquiry-based learning are the Web-based Inquiry Science Environment (WISE) (Benner, 2001), the inquiry page at the University of Illinois, Champaign-Urbana (2001), Lehigh Earth Observatory's Envirosci Inquiry (2001), BioQUEST (n.d.), and the Jet Propulsion Laboratory (n.d.).

Web-based Inquiry Science Environment (WISE)

WISE (Benner, 2001) uses a web-based platform and is structured to be a highly interactive and educational experience. There are about fifty different projects that teachers can select on this website. Students can explore a learning environment that has activities, on-line discussion groups, maps and graphs, and links to more information. In this way, they are able to learn on their own without a guidance structure and choose subjects that interest them. This website has on-line "projects" where students can use interactive, current information on topics, such as malaria, earthquakes, genetically modified foods, and growing plants in space. Teachers can design their own activities, lesson plans, and projects. According to Linn, Clark, and Slotta, "Most teachers who start using WISE projects choose to continue using those projects" (2002, p. 1). Teachers and students have partnered with other institutions, such as National Aeronautics and Space Administration, National Geographic, Monterey Bay Aquarium, and the American Museum of Natural History in order to build interactive real-life situations that they can analyze.

Inquiry Page at the University of Illinois, Champaign-Urbana

The inquiry page at the University of Illinois, Champaign-Urbana (2001) can be used by teachers to facilitate the use of inquiry-based education. The inquiry page provides a virtual community where educators can share their knowledge and experiences of using the inquiry-based approach. The steps for following this procedure have been specifically outlined. The first is "Ask," in which teachers ask their students questions that inspire and challenge them to think about real-world experiences. Then there is the "Investigation" stage in which students gather information to answer these questions. Next is "Create," where they try to create ideas, theories, and thoughts to make connections between the facts they gather during the "Investigation" stage. After that is the "Discussion" stage in which students compare notes, discuss conclusions, and share experiences with the class. This way, they gain knowledge from others as well. Finally, they engage in the "Reflection" process, where the learners make observations and even new decisions about solving the problem, and come to understand the process by which they came to their conclusions.

Lehigh Earth Observatory's (LEO) Envirosci Inquiry

The LEO Envirosci Inquiry website "is an innovative, inquiry-based science resource that utilizes the interactive technologies of a Web browser to explore earth and environmental science" (2000, p. 1). Lehigh University designed this website for the secondary science curriculum program to be used in a variety of curricular subjects, including geology, Lehigh

River watershed explorations, weather, and environmental issues. In the "Environmental Issues" section, there are many activities which are meant to enhance the social science curriculum. The purpose of this site is to present controversial real-life issues that occur in the natural sciences. Students are presented with both sides of an argument and must discuss the pros and cons of the issues. It also invites students to take advantage of the opportunity to study the places important to our society. The LEO Envirosci Inquiry website provides an example of this approach:

> A main goal of this Web site is to present science to K-12 students in a historical perspective by engaging in a detailed study of the Lehigh River watershed. This watershed has a very rich history. The American industrial revolution began here. (Lehigh University, 2000, p. 1)

The LEO Envirosci Inquiry website provides the opportunity to explore science through various activities that broaden science inquiry in the classroom. For example, the "Geology" section consists of exploring, learning, and investigating geological topics. In the exploration, the students learn about "the origin, history, and the structure of the solid earth" (Lehigh University, 2000, p. 1). One of the sections is called "Geology Lesson Plans" and includes a lesson entitled "The Magic of Hydrangeas," which studies the *Hydrangea macrophylla* plants that grow along the riverbank. This is an example of investigating through the use of a website to develop project organization, scientific inquiry, and an experimental plan for growing hydrangea plants to be a specific color due to pH levels in the soil. The website also contains many links to other sites for additional information on plant life, geology, and other natural science websites.

Bio*QUEST*

Bio*QUEST* (Beloit College, n.d.) is a web-based structure that provides a variety of materials including bioinformatics tools, databases, and multimedia resources. It is a curriculum consortium which welcomes collaborative project ideas. This consortium provides many projects and problems in different areas of the science field that encourages students to develop inquiry skills. One example would be a problem-solving task, such as a case study on HIV found in the section dedicated to inquiry learning which can be made into a problem-solving challenge. This allows students to work with large amounts of background information regarding the topic in order to answer general questions provided via the site. It gives the students the opportunity to discuss and debate about their hypotheses. For example, one question is, "Do viruses all evolve the same way in different patients?" In exploring this question, the students can apply what they've already learned from the website about HIV. The site provides sequences of data that help students understand HIV and its effects.

Jet Propulsion Laboratory

The California Institute of Technology has designed the Jet Propulsion Laboratory (JPL) website to provide students with information about the solar system and information gathered about Earth from space (California Institute of Technology, n.d.). The purpose of this website is to help students build a knowledge-base of the solar system that surrounds them, learn about the beginnings of space, search for other planets, and look at satellite topographical mapping of the landmasses on the earth. JPL's mission is to increase knowledge and experience of our home planet through using spacecraft devices on NASA's satellites. The website has several sections including ones about the latest news, features, and multimedia. There are articles, such as the two current ones, *Spitzer and Hubble Capture Evolving Planetary Systems* and *Cassini Captures Saturn Moon Red-Handed.* There are also many quizzes that provide inquiry through questions, hints, images, animations, sounds, and texts.

Furthermore, there are many topics on this website that relate to NASA's space missions. One of these topics is NASA's Shuttle Radar Topography Mission. The students learn by using the inquiry method and activities format. Students can choose from a variety of options, including gallery, quizzes, applications, and related linked icons, in order to learn about the Topography Mission and the earth's surface. This part of the JPL website tests students' knowledge of the geography of the earth, and visually displays 3D maps. Another activity challenges students' knowledge of space travel and extraterrestrial life. This specific section asks students questions and gives supported explanations that justify the answers through a dynamic flash program. One of the fun quizzes on the site tests whether students can tell the difference between science fact and science fiction, using examples from Sci-Fi shows and movies. Students must guess what they think is fact or fiction; the answers might surprise even the best of teachers! After each question, the answer is thoroughly explained, especially on some of the more unbelievable answers.

Website Simulations

Website simulations (Hartley, 2000) are websites where students can simulate various activities that some may consider as being unethical or even somewhat dangerous to perform in real-life. Furthermore, these websites require little financial investment on the part of the teacher. Due to the budget conditions at some schools, a significant amount of materials are not available in many science classrooms. With a virtual simulation, students can do the same activities they would do in a real classroom without needing anything but their computer. Students do not need to be in a lab to do some of their school experiments; they can do them at home. These web-based materials support each of the methods mentioned in this study. They apply the inquiry-based learning method by leading students to answer the questions about a problem to enhance their knowledge and understanding. Also, website simulations apply the direct instruction method through guiding learners to understand the concepts behind the scientific method in the context of everyday living.

Website simulations also apply the problem-based learning method by having the students do a hands-on project on the computer rather than in real-life. These websites apply the hypothesis-based learning methodology through investigating a problem and finding a solution. In simulations, collaborative learning can be applied through variations in solutions. These solutions can be shared with the whole class or can be done separately in groups that perform different tasks to complete an experiment, such as sharing the responsibilities in building a roller coaster in the project, Funderstanding Roller Coaster (Funderstanding, 1994).

In a Spanish high school, teachers had their students take a science pretest of nine open-ended questions before using a web-based simulation. After that, the students had to create "hypotheses about the solution of the problem, as well as the experimental strategy that would permit it to be tested." (Sierra-Fernandez & Perales-Palacios, 2003, p. 1). The procedure is then stated. Subsequently, the students would implement their project. They then came up with their conclusions and recorded whether it proved or disproved their hypotheses. Finally, the students took a posttest and the results showed that "students who used the simulator program in their research activities progressed more significantly in their conceptual and procedural knowledge than their classmates who only used their textbook" (Sierra-Fernandez & Perales-Palacios, 2003, p. 1).

With the demonstration and laboratory work method, teachers can use the simulation in a variety of ways, such as projecting it on to a screen and then asking the students to perform the steps. This is beneficial for the teacher to show the procedure in a safe and controlled environment as well as with a clear demonstration that's easy to view. Moreover, students can either complete the same simulation, or better, use their knowledge from the simulation in a real experiment. From the recitation method, teachers can ask questions about the students' experiments and have them prove their hypotheses through the simulation.

After the students listen to the teacher's lecture, through discovery learning they can experiment by using simulation activities as they imitate real life tasks and gain a better understanding about the projects they've put together, especially if they do not have access to the actual materials. Examples of these website simulations are Net Frog (University of Virginia, 1994), Funderstanding Roller Coaster (Funderstanding, 1994), IrYdium Chemistry Lab (University of Carnegie Mellon, 2003), Java Applets on Physics (Fendt, 2003), Parallelgraphics (Parallelgraphics, 2002), Amazing Space (Amazing Space, n.d.), Exploring Earth (Class Zone, 1995), Geo Mysteries (Educational Web Adventures, 2000), CosmicQuest (The Children's Museum of Indianapolis,1999), The Mathematics of Rainbows (University of Minnesota, 2003), and The Center for Science Education (University of California – Berkeley, 2001).

Net Frog

Using Net Frog (University of Virginia, 1994), students are able to dissect a virtual frog by receiving instructions from a recording and movie in order to learn about anatomy and to compare frog and human physiology. Students can practice their knowledge of the frog's body by correctly selecting and identifying its internal parts. Each section of the site has many different activities that students can use to learn about dissecting frogs. These sections also provide supporting information and evaluate what the students learn. The site is comprehensive and allows students to learn how to dissect frogs without actually doing it. It provides an alternative for students who are uncomfortable dissecting a real frog for various reasons. Net

Frog provides illustrations of the dissections with images, links, and narrations in order to make the educational process more fun and enjoyable. For example, there are illustrations for setting up the frog for the dissection, making the incisions, finding the organs, and "cleaning up" afterward.

Net Frog was created six years ago by Mable Kinzie, an associate professor of instructional technology, at the University of Virginia. Since its inception, the number of users of frog dissection online has increased to more than a half-million users. Kinzie says, "Our site is one way students can learn about frog anatomy without actually dissecting" (Kinzie, 2000, p. 1). This site is user-friendly through step-by-step dissection processes. Instead of brandishing pins, scalpel, and forceps typically used for dissection, the students maneuver their virtual equivalents with a mouse. With a few clicks, students make incisions with their virtual scalpel, secure the pins, and identify the frog's anatomy as they would during a real dissection. During a study, Kinzie researched how well students learn using web-based dissection simulations compared to the real thing:

> We conducted research in a number of high school classes, when students were tested on their knowledge of frog anatomy and dissection, we found that the ones using the interactive materials did every bit as well as students who actually dissected. They actually did a little better. (Kinzie, 2000, p. 1)

Kinzie also found that when the computer programs were used, student engagement increased (Kinzie, Foss, & Powers, 1993). When used as a tutorial to prepare for a real dissection, Kinzie found that students exhibited more confidence and greater progress. The scientific community and the nation's schools have compared students using web-based simulations and students without the simulation (Akpan & Andre, 2000). The experiment was conducted using observations of four experimental conditions: the frog simulation before live dissection, live dissection before the simulation, just the simulation, and just the live dissection. Results from the study indicated that the students practicing with the simulation before the live dissection or only using the simulation learned more about anatomy than students who did the dissection before the simulation and those only performing the dissection.

Aside from the educational benefits of using simulations, schools would also avoid the controversy that can occur over conflicts in morals and beliefs about the dissection of deceased amphibians. DeRosa (1986) remarks that "in one year alone, U. S. suppliers shipped approximately 5 million frogs for education and research purposes" (as cited in Akpan & Andre, 2000, p. 1). This is considered by some to be a large waste of animal life. He, among other researchers, has acquired evidence that the dissection of certain species fosters negative attitudes pertaining to these species and causes students to experience psychological trauma.

Funderstanding Roller Coaster

On the Funderstanding Roller Coaster (Funderstanding, 1994) site, students can explore physics and gravity by creating their own roller coaster. This website also considers students' preferences because it allows them to create their own coaster. They can adjust height, loops, mass, and friction simultaneously, while being able to apply the many different dimensions that a real roller coaster would use. Through this, they can learn about friction, gravity, and centripetal motion. If students have difficulty in any of the steps of the design, the Funderstanding Roller Coaster website provides a help page that can answer their questions. In addition, students can obtain information from a list of topics, such as energy, force, and inertia in order to have a better understanding of how to create their design.

IrYdium Chemistry Lab

The IrYdium Chemistry Lab (University of Carnegie Mellon, Pittsburgh, 2003) is a website where students can choose from a variety of chemical substances and combine them virtually. Learners can get instant results without risk of having an accident. This simulation provides a user's guide for students, which also includes a description of each component in the design, such as how to run it, how to retrieve homework problems, how to use the tools and features, and how to obtain information about the different types of solutions. The Chemistry Lab project displays the molarities of substances, the form that the newly created substance takes (aqueous, solid, gas), the name of the formula that is created, and other relevant information. The students can enjoy doing chemistry by means of this website project without using traditional materials, such as chemicals, flasks, and test tubes. In addition, students can enhance their work by utilizing different activities, charts, and diagrams. This virtual project also provides teachers with an opportunity to use chemicals (that are sometimes limited or even considered dangerous in schools) in a virtual way in their classroom (University of Carnegie Mellon, Pittsburgh, 2003).

Java Applets on Physics

Java Applets on Physics (Fendt, 2003) contains many different simulations to help students learn about motion. This site provides a useful section on physics, as well as practical applications for astronomy and mathematics. The students can manipulate all the different elements such as weight or direction, depending on which simulation they're doing. In this way, students can see what effect a change has and try it many times until they reach the correct answer. The physics section includes categories such as mechanics, oscillation, electrodynamics, optics, theory of relativity, thermodynamics, physics of atoms, and nuclear physics. These categories provide illustrations of different physics concepts, such as motion with constant acceleration, simple pendulums, generators, refraction of light, and time dilation. The applet for astronomy includes two forms of astronomy: spherical astronomy and stars, which can be used to aid students in comprehending the universe, planets, and stars. Lastly, the applet for mathematics has nine different types of mathematics that students can use to help them understand math concepts, including arithmetic, elementary algebra, and plane geometry. Each simulation has a brief explanation on how the concept can be applied in real life.

Parallelgraphics

Parallelgraphics (Parallelgraphics, 2002) includes two three-dimensional (3D) projects that can be useful in the classroom. There are two sections that are related to science: "Solutions" and "Event Modeling." The "Solutions" section has several subcategories such as "Virtual Manuals," "Distance Education," "Real Estate, and "Interior Design." An example of these subcategories is "Distance Education," which contains a 3D periodic table that demonstrates the atomic particles, such as protons, neutrons, and electrons, of the different chemical elements. Students can click on an element on the periodic table to check out statistics on its atom as well as see its atomic particles and watch them move in relation to the rest of the atom. They also learn about electrons, protons, and neutrons.

Under the other section on this website, "Event Modeling," there are many different segments; three of them can be used in the science classroom. One segment is called "Universe." On this web page, students can wander through a virtual 3D universe, launch a shuttle, and land on the International Space Station. The next segment is "Gagarin's Spaceflight," where students can view Gagarin's actual spaceflight from different perspectives and discover the inner parts of the cabin as well as view the outside of the ship. The last segment is called "The End of MIR." This site allows students to see different viewpoints from the virtual space station, MIR. For example, students can rotate the view, and choose viewpoints from MIR to the earth and from various regions of Earth to MIR. In addition, students can find out the time, speed, and apogee of the spaceship when changing the view.

Amazing Space

Amazing Space (Amazing Space, n.d.) contains two sections, which are "On-line Explorations" and "Capture the Cosmos." The first section, "On-line Explorations," consists of numerous segments that are related to science, including "Planet Impact!," "Mission Mastermind," and "Galaxy Hunter." Through these segments, students can learn about topics such as gravity, mass, and acceleration in space. These segments allow students the opportunity to discover space in an enjoyable and interactive way, since they cannot experience space travel firsthand. Within the simulation, they are also able to manipulate the statistics, such as comet angles or speed, to discover what would happen in a real situation in space. For example, in the game "Planet Impact," students choose the speed and approach angle of the comet, and see if it would hit Jupiter. The other section of Amazing Space, "Capture the Cosmos," provides teachers with activities that deal with planets, galaxies, comets, and black holes.

Exploring Earth

Exploring Earth (Class Zone, 1995) is a website where students can explore the world of earth science through topics, such as erosion, plate tectonics, rock formation, and the water cycle. There is a wide variety of simulations as well as animations ranging from being able to navigate the path of a raindrop to navigating through the Milky Way and neighboring galaxies. This website is a complement to a high school earth science textbook and puts many of its units, such as "Investigating Earth," "Earth's Matter," and "Dynamic Earth" on-line. Each unit refers to earth science and provides images and links that students can use to learn more information. The purpose of this site is to reinforce students' comprehension of earth science. Exploring Earth uses many different activities that are supported by animations, images, links, and graphics to help students study and make observations about the data. One of these activities is about the Mount St. Helen's eruption. It has time-lapse video, an interactive tool, effects, and detailed explanations for each element and visual. It also provides teachers with tips for creating lesson plans. Some of these tips are ideas for discussion questions and investigations, how to help students understand the mechanics of earth science, and how to choose appropriate media.

Geo Mysteries

Geo Mysteries (Educational Web Adventures, 2000) is a website that helps students become interested in geology and the layers of the earth. It has an illustrated timeline which chronicles the progression of life on Earth with each period accompanied by graphic pictures of fossils. This site uses computer graphic simulations, and has a fun dinosaur detective that guides students in exploring the website. On the website, three activities are set up as mysteries to help students learn about the origins of rocks, fossils, and minerals. The three 'mysteries' were: "The Mystery of the Floating Rock," which describes the surface and interior composition of rocks "The Mystery of the Broken Necklace," which illustrates different types of fossils, such as trilobite, cephalopod, and crinoids and "The Mystery of the Golden Cube," which distinguishes between rocks, minerals, and fossils. Learners discover the different attributes of rocks and minerals and how they're physically and elementally different. These activities encourage students to not only take a closer look at the world of geology, but also compare fossils from ages ago to modern creatures in order to show them the relationships between the various species.

CosmicQuest

CosmicQuest (The Children's Museum of Indianapolis, 1999) includes two sections where students can simulate and explore different areas that pertain to space. The two sections include "Living in Space: Design a Space Station" and "Field Guide to the Universe." The first section, "Living in Space: Design a Space Station," is an on-line game where students can explore the possibility of human survival in space. It shows what is necessary for humans to have in order to live in space, as well as what they may need to work and succeed there. Students can examine a series of problems: how to breathe, what to eat, and how to produce power. This site includes an experiment where students can choose what is necessary for them to take with them into space. There are many different activities within this experiment that can help students create an environment in a spaceship, such as being able to choose which gases people need in order to breathe and how much water they need to survive in that environment. The other section is "Field Guide to the Universe," which describes our solar system and has pictures of the sun and the different planets, which are actually links that students can click on to find out more information about each planet.

The Mathematics of Rainbows

The Mathematics of Rainbows (University of Minnesota, 2003) discusses how rainbows are formed. It also explains how the angle of a rainbow in the sky is produced when the sun is low on the horizon and that people are most likely to see it at these times. The website provides students with an activity that allows them to build a rainbow. This activity requires students to change the angle of the rays of light in order to create the rainbow whether it be to make the rays horizontal, parallel, or even vertical. This is done by changing the degree and wavelength formats. The site includes many analyses of the experiments. Students experiment with rays hitting water droplets at different locations; each one is spread around at different angles. This site provides other applicable information that includes quizzes regarding light, rays, rainbows, reflection, refraction, and a brief description on how light travels. They can also seek out the various positions where the angle is intense.

In addition, The Mathematics of Rainbows' website has two final challenge questions in the conclusion section. The students must think about why rainbows include all the visible light colors, why it looks like a piece of a circle, and why the colors appear in a certain order. For instance, the learner retains information about why the red appears on the peak and why purple appears on the base of the rainbow. The learner, then, by doing so, learns about the visible light spectrum. This website also lists the wavelengths for each color and provides a challenging problem which the students have to solve that refers to how light deflects off of water.

The Center for Science Education

The reputation of The Center for Science Education at The University of California – Berkeley Space Sciences Laboratory maintains a high standard for superiority in space science education and community outreach (University of California – Berkeley, 2001). This Center develops innovative programs that support educators, students, and the general public. It provides information about space science, which is the study of the solar system, and merges arithmetic, scientific disciplines, and technology. Students are able to learn about their environment, the planet Earth, and the solar system. The Center's goals consist of increasing the knowledge of science for the general public, enhancing scientific teaching and learning processes, assisting the integration of science in education and the community, reaching a wide variety of learners in order to increase their interest and participation in science, and providing accessible opportunity for space science resources.

In addition, The Center for Science Education has showcased "Sun-Earth Day 2004-2005: Ancient Observatories – Timeless Knowledge" (University of California – Berkeley, 2001). This was a part of the Chaco Culture National Historical Park and is dedicated to "solar alignments and solar traditions through time" (2001, p. 1). The Traditions of the Sun site permits learners to explore a virtual park, peruse research of the sun, and learn Native American practices of using the alignment of the sun to plant and harvest their crops. Students "can pan and zoom satellite images of the canyon as well as aerial photos of the 'great houses,' which are the enormous ancient structures found in the park" (2001, p. 1). Furthermore, students can click on 'points of interest' icons to display above ground photos, historic visuals, and a QuickTime virtual reality video. This featured destination includes more than three hundred images and videos. The Traditions of the Sun project is divided into five sections that include Regional, Park, Downtown, Pueblo Bonito, and Casa Rinconada. The Center supports these sections with additional information about each point of interest (2001).

Real-Time Data

Real-time data supports the inquiry learning method because it helps students investigate their hypotheses by collecting data and information available on these websites. For example, students can use these to find current information on such topics as weather, earthquakes, volcanoes, and tides. There is a need to provide both theoretical and practical experience in the classroom. What most students receive from lectures and demonstrations is theoretical. Real-time data fills in the need for practical experience. According to the Digital Library for Earth Science Education (n.d., p. 1), real-time data "can make things real and engaging for the students" and "is what scientists actually do." Students can also use real-time data to find problems, create solutions, collect information, and compare their findings with their hypotheses, which follows the procedures for the direct instruction method.

With teacher supervision, students can apply the problem-based learning method by selecting a topic for their project based on information that is available from real-time data websites and start planning the project. They can also apply this method by using the information from real-time data websites to design their project and observe an event to deepen their understanding of these events. The hypothesis-based learning method can apply real-time data websites through helping students collect information to form and test their hypotheses. Students can also use these websites to evaluate the information that helped them develop their hypotheses.

Finding the real-time data in a cooperative learning method strategy requires each student to collect different information in order for the class to complete their projects. Involving the demonstration laboratory and work method, teachers can use examples from real-time data to explain different phenomenon, such as volcanoes, hurricanes, and tsunamis. Teachers can use the recitation method to ask questions about these phenomena and then use the information to predict what might happen based on what the students have already learned. Lastly, students using real-time data with their discovery learning can find out relationships between different elements on their own or solve problems in order to make their own decisions for the best solutions as actual scientists would do. The researcher found five websites that use real-time data: DataStreme Atmosphere (American Meteorological Society, 2003), Volcano World (University of North Dakota, 1995), The Center for Operational Oceanographic Products and Services (National Oceanic and Atmospheric Administration, 1983), the United States

Geological Services Earthquake Hazards Program (The National Earthquake Information Center, n.d.), and WhaleNet (Wheelock College, 2001) websites.

DataStreme Atmosphere

DataStreme Atmosphere (American Meteorological Society, 2003) has compiled many subjects to facilitate students' learning about the weather. According to the American Meteorological Society, "its main goal is the training of Weather Education Resource Teachers who will promote the teaching of science, mathematics, and technology using weather as a vehicle, across the K-12 curriculum in their home school districts (2003, p. 1)." This website has information about the weather that is recorded each day, such as the weather in all fifty of the United States including Alaska, Hawaii, and additionally Puerto Rico/U. S. Virgin Islands. This website covers not only current weather, but also satellite watches, warnings, advisories, and forecasts.

Volcano World

On the Volcano World (University of North Dakota, 1995) website, students can learn the dates of volcanic eruptions or a volcano's current activity and locate recently updated information. This website provides spectacular photographs of volcanoes worldwide as well as on Earth and Jupiter's moons and on other planets such as Mars and Venus. The "Volcano Observatories" page explains the principle aims of monitoring volcanoes, provides information about how volcanologists predict an eruption, and supplies a brief description of the tools and equipment that these observers use to measure volcanoes. The Volcano World website provides teachers with different video clips of erupting volcanoes, such as the Stromboli and Mount Etna volcanoes.

The Center for Operational Oceanographic Products and Services

The Center for Operational Oceanographic Products and Services website was developed by the National Oceanic and Atmospheric Administration (NOAA) (National Oceanic and Atmospheric Administration, 1983). The purpose of the NOAA website is to provide information for learners about natural wonders such as hurricanes, tornadoes, and earthquakes. It has multiple topics for students and teachers to access.

The National Oceanic and Atmospheric Administration (NOAA)'s main website has eight central categories, which include weather, ocean, satellite, fisheries, climate, research, coasts, and charting and navigation. Each category has valuable resources for students to use in their problem-based learning. For example, "The National Weather Service is the primary source of weather data, forecasts and warnings for the United States. Television weathercasters and private meteorology companies prepare their forecasts using this information" (National Oceanic and Atmospheric Administration, 2004. p. 1). This information is free for students and all others within the public domain. The weather category provides information on weather watches, warnings, and forecasts. The warnings include the most recent information on tornadoes, hurricanes, flash floods, flood, winter storms, etc. The forecasts consist of real-time observations and broadcast data from the NOAA Ocean Prediction Center.

The Center for Operational Oceanographic Products and Services's website specializes in historical and real-time observations as well as predictions of water levels, coastal currents, and other tidal data. The information is divided into different sections, such as preliminary water level data, verified/historical data, ancillary data, inventories, and other information about sea level trends, benchmarks, and accepted data. It has many links to websites of oceanographic interest and provides a great deal of information about ocean tides. The National Oceanic and Atmospheric Administration (1983) mentions that this system allows the student:

> …to obtain tidal predictions computed by CO-OPS for more than 3000 water level stations. The publication of full daily predictions is limited to fewer stations. These stations with full daily predictions are referred to as "reference stations." The remaining stations are referred to as "subordinate stations." Tidal predictions for the subordinate stations can be obtained by applying specific differences to the times and heights of tides of the specified reference stations. (p. 1)

United States Geological Services Earthquake Hazards Program

The United States Geological Services Earthquake Hazards Program website (The National Earthquake Information Center, n.d.) reports on worldwide earthquake activity from the last seven days. It lists the exact time, location, latitude/longitude, depth, and magnitude of different earthquakes. The National Earthquake Information Center (NEIC) provides urgent information about earthquakes that occur worldwide to "concerned national and international agencies, scientists, and the general public" (n.d., p. 1). In addition, "…the NEIC compiles and maintains an extensive, global seismic database on earthquake parameters and their effects that serves as a solid foundation for basic and applied earth science research" (n.d., p. 1). This site also provides links to videos which offer additional information about earthquakes.

WhaleNet

WhaleNet is website that students can use which teaches them different kinds of information about whales and other marine animals (Wheelock College, 2001). According to Jazlin Ebenezer and Eddy Lau (2003, p. 18), this website provides "information on the date and location for each sighting of a right whale named Rat." Students can put numbers for Rat's latitude and longitude in to a distance generator to see where he would go if that was his starting point. Instructors are also able to ask questions about outside circumstances related to Rat's location and analyze data to help students answer these questions. The site is divided into various areas including "ASK a Scientist," which highlights a new scientist in the field every week. "WhaleNet Tour" gives teachers and students tools to look up information about the topic of whales. *How to Find* is a search engine for questions related to this field of study within the website. "Search WhaleNet" is another search engine on the website, which is powered by Google, and also helps students find information about the topic and other related fields. "WhaleNet Index" is composed of various stories and articles surrounding the topic of whales. Finally, there is "Email WhaleNet" where teachers, students, and even the general public can email questions to experts in the field and receive answers to these questions.

Furthermore, this website appeals to three different audiences including students, teachers, and the general public. The audience is able to find many resources that explain the climate and weather that whales live in, such as hurricane information about wind speed, wave height, and descriptive terminology. Students can also find additional links to learn about different species of whales and the use of satellites that lead to the identification of the whales' locations. Also, it provides movies, visuals, and slide shows of real-life whale explorations which allow the opportunity to listen to whales, watch their movements, and analyze the differences between species.

Problem-Based Learning Websites

Problem-based learning websites support the described science education methods. According to Macinnis (2003), a problem-based website is an "independent study which leads you to find out something new," (p. 1). These websites use this definition as a basis for their structure. These projects are designed to provide students with experiences that they would not traditionally receive through routine classroom instruction, and the projects support the inquiry learning method through giving students the opportunity to investigate their own questions and choose a method to find a solution to the problem their project presents. These websites also support the direct instruction method because teachers assign individual students in to groups and give them directions to do the activities. Additionally, teachers not only allow the groups to develop their own problem to investigate, but constructively direct and guide them to the correct answer.

Furthermore, these websites apply the problem-based learning method because they allow students to pursue their own individual interests and give teachers the chance to supervise students' work while it is in progress (Collette & Chiapetta, 1989). These problem-based websites support the hypothesis-based learning method as well. Students can collect information and compare their findings to develop their hypotheses. The Internet can be used to extend cooperative problem solving activity around the world.

> Educational problem solving projects are, as yet, the least common kind of Internet-based activity that involves precollege students, but they are among the best examples of how asynchronous connectivity can be used to support and enrich precollege curricula (Harris, 1995, p. 1).

These online resources are to be used as a supplement for problem-based learning; Harris's research has shown that it is not a replacement. Some examples of websites using the problem-based method include the Genetic Science Learning Center (University of Utah, 2003), the Education Center on Computational Science and Engineering (San Diego State University, 1997), Plankton and Ocean Currents (Coastal Ocean Observation Laboratory, 2003), Spring Acid

Rain Watch (Québec-Canada Entente for Minority Language Education. (2003), and the Gulf Stream Voyage (The Center for Innovation in Engineering and Science Education, 2004).

Genetic Science Learning Center

The Genetic Science Learning Center (University of Utah, 2003) provides many different activities and guides to help students design their science projects. There are many types of activities including interactive web activities, "Print and Go" activities, and wet lab activities. Interactive web activities, such as "Inside a Cell," "Build a DNA Molecule," and "Transcribe and Translate a Gene" allow teachers to make creative and accurate illustrations for students to manipulate and experiment in order to learn concepts of genetics. "Print and Go" activities, such as "Genetic Screening of Newborn Infants: What Should We Test and Why?," "From Gene to Protein Web Quest," and the "Tour of the Basics Web Quest" can be useful for concept mapping activities in the classroom, and for small and large groups as well as individuals. Wet lab activities such as "Does Sunscreen Protect my DNA?," "Mystery Yeast Mutation," and "Colorful Electrophoresis" are labs and hands-on activities that use inexpensive materials to help students visualize the concepts of genetics. In addition, teachers can use appropriate activities provided by the website, such as "The Basics and Beyond" and the "Genetics Disorder Corner."

Education Center on Computational Science and Engineering

The Education Center on Computational Science and Engineering (San Diego State University, 1997) website includes different projects that challenge students to explore science individually or in small groups. This website is divided into three sections: "Regional WorkBench Consortium," "Interactive 3D Modeling for Earth Science Education," and "Written in Stone" earthquake animations.

The first section, "Regional WorkBench Consortium," helps students improve their understanding of geography by looking at three-dimensional (3D) models of the California landscape. For example, a teacher could assign the students to explain how certain land formations may have been created using supporting evidence provided by the 3D simulation. The simulation provides more information than a photograph, and is more accessible than an actual mountain. The second section, "Interactive 3D Modeling for Earth Science Education," incorporates a program called "GeoWall." "GeoWall" uses projection systems to visualize the structure as well as dynamics of the earth to help students understand spatial relationships. The last section, "Written in Stone" has earthquake animations, provides animated videos explaining how earthquake movements are related to shifts in plates, as well as seismic waves. These animations include visual explanations for some complex processes that are carried out during earthquakes.

Plankton and Ocean Currents

Plankton and Ocean Currents was created by Rutgers Marine and Coastal Sciences. Plankton "is microscopic plants and animals floating in the ocean" (Rutgers Marine and Coastal Sciences - Coastal Ocean Observation Laboratory, 2003, p. 1) and is the base of the food chain that maintains marine life. Small fish and invertebrates eat plankton, and, thus, become bigger and turn into food for larger animals. Therefore, scientists are interested in keeping track of where blooms or groupings of plankton occur as well as where they drift over time.

Fishermen depend on knowing where the plankton is because, where the blooms occur, they often find the fish that feed on plankton. The students can collaborate together to work on this project and follow the four steps. They research information about radar, specifically CODAR, which follows ocean currents. Using the next step, students calculate the locations using real CODAR information, and then analyze the data to predict where the currents will move next. As a final step, students use real-time data and apply what they've learned to complete the prediction for the plankton's location.

Spring Acid Rain Watch

Spring Acid Rain Watch is a collaborative project where students from different classrooms around the world participate in recording the amount of acid in rainwater in their area (Québec-Canada Entente for Minority Language Education, 2003). The website contains an overview, a timeline, research information for students and teachers, and past results from different participants. The research is coordinated among the schools with a timeline. The steps for doing the project are well-organized in this website. Students can communicate with each other via a message bulletin board and meet the other participants during the activity, as there are students participating from all over the world. In order to begin the project, they should communicate as a team, and then relate what they already know to form a hypothesis. They can then experiment by gathering data from their area and analyze it in order to come to a conclusion. Finally, they post their findings on the website, and compare their results with those from other schools.

The Gulf Stream Voyage

The Gulf Stream Voyage is a collaborative group project, and the purpose of this activity is to find the likely location for the Yellowfin Tuna as the students are a group of fishermen and must track the tuna (The Center for Innovation in Engineering and Science Education, 2004). Students use data gathered from satellites about geographic topography of the ocean floor and temperature fluctuations to fill out a worksheet and determine the movements of the Tuna. The webpage provides maps, visuals, and additional data for students to use for their research. It contains links to other pages that provide additional information about tuna, seasons, and ocean water temperature. Utilizing the information they have gathered, the students locate the tuna and report the location. The webpage provides discussion questions for the group, has a section where students can ask a real marine biologist questions, and a section for teachers which outlines a lesson plan and provides information about using the Internet in their classrooms. There are several other projects that teachers can choose from to meet their instructional objectives. These include how the Gulf Stream affects climate, biology, and maritime movement.

Are Science Web-based Resources Better than Traditional Methods?

There is debate about the quality of learning when comparing traditional methods and online science resources. The traditional side of the spectrum thinks that face-to-face interaction is the best way to educate individuals, but online resources are changing the way instructors teach. Online resources have several key benefits when looking at student/ teacher ratios. Some of these benefits will be discussed in detail.

Throughout the nation, individuals in education are feeling the squeeze of budget cuts and baby boom retirements. These two factors are causes for the rise in student-to-teacher ratios. This leads to decreased one-on-one interaction in the classroom. This is where online science resources can fill in the gap. Online science resources let students access the information at any time and promote extended self-sufficient learning. According to Laurillard (1996, p. 1):

> While traditional teaching methods focus on having students "attending" (listening and reading) for a vast majority of their contact hours, computer-based learning, on the other hand, can refocus student activity by giving them more opportunities for "practicing" and "articulating": the challenge is to exploit the capability of the computer to offer interactive practice of a subject.

Online science resources and information for students and teachers are more accessible. According to Bell, Bush, Nicholson, O'Brien, & Tran (2002), there is a continuum to online science resources. Some instructors will use these resources to supplement their classes while others will not use face-to-face interaction and use only the website as the interaction with students. Student learning did show that "computer-based media were capable of supporting the more practice-oriented aspects of the learning process that the traditional methods did not" (Laurillard, 1996, p. 1). For example, some students who struggle with learning may have a hard time understanding concepts without having repetition or the opportunity to practice the concept. Engaging in on-line activities that can demonstrate multiple steps of the material being covered and having the capability to backtrack and try again allows some room to correct errors. Students are able to develop their higher thinking skills by using web-based materials on their own.

Adding to the Knowledge of Teachers

"Technology can help science teachers perform their jobs more efficiently and instruct students in a variety of ways" (Collette & Chiappetta, 1994, p. 288). Technology has become an effective learning tool in the classroom today. Teachers are able to experience hands-on activities and help students to enhance their interest in academic subject matters. Cain defines instructional technology as teachers and students using non-traditional electronic tools and devices, such as the Internet, to help to complete the task for student learning (2002). Teachers are also able to add to the students' experience and challenge their problem solving through learning with Internet technology. According to Trowbridge and Bybee, "new instruments and techniques enable new observations of and scientific explanations about the world" (1996, p. 326) emphasizing that using different tools to view the world can change one's perspective of it. Technology provides an effective tool for interaction between science and students, and supports the teachers' strategies as well.

The advantage of using Internet technology is to provide access to presented media, such as texts, books, sounds, movies, and images. It gives teachers a way to manipulate multiple forms of media and incorporate it into their teaching strategies and methodology. The technology presents useful facts and many types of information relevant to the curriculum, and can, therefore, be used as a resource for lesson planning. Web-based materials can enhance teachers' performance in dynamic presentations and can be used to test students' knowledge through activities.

The Internet holds many rich and valuable resources that are increasing over time, and has become a worldwide library for teachers and students to use. Teachers can now enrich their instructional techniques with the use of real-time data in complex simulations by satellites (Trowbridge & Bybee, 1996). Teachers are now being directed to the Internet rather than to libraries to find information for and about classroom operations (Lowe & Vespestad, 1999). They use the Internet to enhance their science teaching by researching the desired content and using on-line lesson plans and other curricular-related materials. According to Parkinson, "The internet and the web provide teachers and pupils with a vast amount of information and resources…" (2002, p. 94). The Internet offers direction to make the most of learning and reduce the time spent on researching. Neuman studied the success level of research conducted on the Internet. The research found that the traditional methods of researching has its own cognitive structure and that finding information on-line requires higher order cognitive skills; "those participants who were able to move to this higher level, engaging in reflection as they interacted with the system, were ultimately successful in finding the information they sought" (Neuman, 1997, p. 1). Using the Internet for research is not necessarily more time-consuming or less structured. Rather, this study found that it's an exercise in higher order thinking skills and expanding researching techniques.

Through telecomputing, teachers are able to search through database materials locally or worldwide. The teachers can design their own databases, which are defined as "electronically stored information" (Carin & Sund, 1998, p. 327), to offer with highly exceptional technologically-advanced resources in the classroom. In addition, using the Internet adds to the teachers' knowledge of recognizing the valuable resources that are available on the Internet. According to *Internet Environments for Science Education,* teachers need to be literate in using web-based materials to know how to use the knowledge, critique it, and understand in depth about learning sources (2004).

Teachers can collaborate with their peers in activities; connecting the professionals through the use of the Internet (Dickson & Irving, 2002). Communications technology has also been used to create various learning communities. Learning communities, such as "Tapped In" (Tapped In, 1995), consist of teachers and students, and use science information that has been integrated with technologies available on the World Wide Web. Learners around the world can exchange scientific data and compare answers and conclusions (Trowbridge & Bybee, 1996). Also, using group discussions or blogs can promote forums to allow learners to connect with peers, and permit teachers to examine students' ideas more clearly. For example, Hsi, a graduate student with a CLP (Computers Learning Partner-electronic Library Network Project), designed an on-line discussion tool to increase students' knowledge through collaboration and discussion (Linn & Hsi, 2000).

The Internet can provide technical support for teachers, especially for teachers who are interested in asynchronous forms of communication. The benefit of using asynchronous forms is to help teachers break the barrier of scheduling problems in schools. For example, teachers can use email to communicate with parents, administration, and other teachers in order to increase or share their knowledge about the scientific content.

Teachers can use tutorials to their advantage for additional assistance to students in activities or assignments (Trowbridge & Bybee, 1996). The Internet can provide tutorials in a traditional question-and-answer format. Tutorials can also offer opportunities for students to manipulate information and change the effects until they reach the correct conclusions or find evidence that supports the hypothesis. Teachers can use tutorials for personal guidance and to provide an environment which is safe for the students, without needing a monitoring system or involving hypothetical risks. Furthermore, teachers can use tutorials as scaffolding for their students in learning Internet technology. For example, teachers can introduce some Internet tutorial activities that allow students to type their answers, correct their errors, and analyze the information to enhance their project.

Negatives of Using the Internet

When students use Internet technology, it can cause several negative effects. The Internet has several downsides when used in the classroom. These downsides encompass the social, cognitive, and emotional aspects of student learning. These negative effects include students relying too much on technology, emphasizing appearance over content, plagiarism, wasting time by using the Internet, and having the Internet server provide bad service (Sheneman, 2003).

Relying Too Much on the Internet

The first negative effect that the reviewer found was that students relied too much on the Internet to get information. Students who relied too much on technology isolated themselves from interacting with others. These students ignored valuable resources available in books and other non-electronic resources. Furthermore, these other non-electronic sources were often more reliable than the sources found on the Internet (Aaron Spurr, personal communication, February 13, 2004).

Emphasizing Appearance over Content

The next negative effect was that students were emphasizing appearance over content. According to Lohr (2003), some websites had flashy graphics that looked good, but lacked valuable information for classroom use. Because students paid too much attention to appealing graphics on websites of poor quality, they were distracted from utilizing less graphically appealing sites that offered valuable information and material. These deceptively attractive sites might not contain accurate or valid information (Aaron Spurr, personal communication, February 13, 2004).

Plagiarism

The third negative effect was the problem of students plagiarizing information from the Internet. Students were provided with easy access to prewritten essays or assignments over the Web. They were able to cut and paste, and thus were stealing information. "The New York Times identified dozens of Internet sites that sell term papers. One student in a New York City high school said 'A lot of people download papers and just change the names. There aren't a lot of original papers that get written anymore'" (Norman, 2002, p. 1).

Time Wasted Using the Internet

Another negative effect was that using the Internet wastes time. It was possible that teachers answering emails could take more time than having the teachers meet with their students face-to-face to address their questions personally. In addition, some teachers depended on these websites to prepare their lesson plans. However, these sites often had unreliable or incomplete lessons. The fact that website addresses often change frequently meant that teachers could also be wasting their time trying to find websites they have used before (Sheneman, 2003).

Internet Server Providing Bad Service

The last negative effect that the reviewer found was that the Internet has technical problems from time to time. Search engines have been hard to gear toward specific desired aspects of learning, and often the definitions of what was found on the given page were not accurate. Internet servers have crashed, emails have been deleted, accounts have been stolen, viruses have infected computers, large files have taken great amounts of time to download, and webpages have become deleted after being used for a reference (Francek, 2000).

In essence, the implementation of web-based material has had countless benefits in supporting secondary science curriculum, but there were also many negative effects that teachers should consider in order to avoid potential problems in their future use of the Internet in the secondary science classroom. Some of these aspects include the possibility of students relying too much on technology, emphasizing appearance over content, plagiarism, time being wasted by using the Internet, and the Internet server providing bad service. If teachers do not recognize and avoid negative effects as soon as possible, using the Internet could become problematic (Sheneman, 2003).

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, web-based materials are supportive in applying long-standing teaching methods and strategies in secondary science education, as well as improving teacher education and intercommunication. Teachers use many teaching strategies in the secondary science classroom. By using a variety of websites to enhance the process of learning, teachers can obtain reliable results because these websites help teachers prepare effective lessons, deliver information quickly and easily, and provide a forum for student interaction. Classroom lesson plans can be varied in their structure and content to provide a stimulating learning environment for students. The Internet has many science websites that provide different activities, real data, and quality information. Students will be able to engage in their schoolwork in a modern and intriguing way by using the Internet as a resource. From all the data collected, this review concludes that the Internet provides more positive effects than negative effects in the science classroom. The reviewer finds that on-line resources support and enhance the four referenced teaching methods; inquiry learning, direct instruction, problem-based learning, and hypothesis-based learning.

In the years to come, teachers will increase their use of the Internet as a learning resource. The Internet will continue to provide many quality websites that will allow students to learn more effectively and will provide new means for interaction with teachers and other students. The methods that teachers use to promote learning in a virtually-stimulated environment will enable their learners to apply new knowledge in real life situations. Integrating technology into the secondary science curriculum will help secondary students learn about science and technology at the same time. The integration of these two areas in the field of education will also help teachers with their daily work in the classroom by making lessons easier to teach.

In future research, the ways in which teachers will be educated in technology would have to be much more thoroughly explored than has been done in this study. Using more published research by numerous authors of varying opinions will be helpful in supporting the use of the Internet in science teaching methodology. Also, studying the application of this knowledge in a less technologically-advanced country, such as my home country of Saudi Arabia, would prove to be a useful venture.

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APPENDIX

Inquiry-Based Learning

- "BioQUEST Curriculum Consortium" is available at http://www.bioquest.org/
- "Inquiry Page" is available at http://inquiry.uiuc.edu/
- "Jet Propulsion Laboratory" is available at http://www.jpl.nasa.gov/
- "Lehigh Earth Observatory's Envirosci Inquiry" is available at http://www.leo.lehigh.edu/envirosci
- "The Web-based Inquiry Science Environment (WISE)" is available at http://wise.berkeley.edu/

Website Simulations

- "Amazing Space: On-Line explorations" is available at http://amazing-space.stsci.edu/resources/explorations/
- "CosmicQuest" is available at http://www.childrensmuseum.org/cosmicquest/index.html
- "Exploring Earth" is available at http://www.classzone.com/books/earth_science/terc/navigation/home.cfm
- "Funderstanding Roller Coaster" is available at http://www.funderstanding.com/k12/coaster/
- "Geo Mysteries" is available at http://www.childrensmuseum.org/geomysteries/index3.html
- "IrYdium Chemistry Lab" is available at http://ir.chem.cmu.edu/irproject/applets/virtuallab/Applet.asp
- "Java Applets on Physics" is available at http://www.walter-fendt.de/ph14e/
- "Net Frog" is available at http://curry.edschool.virginia.edu/go/frog/home.html

- "Parallelgraphics showroom" is available at http://www.parallelgraphics.com/showroom/
- "The Center for Science Education" is available at http://cse.ssl.berkeley.edu/
- "The Mathematics of Rainbows" is available at http://www.geom.umn.edu/education/calc-init/rainbow

Real-Time Data

- "DataStreme Atmosphere" is available at http://dstreme.comet.ucar.edu/index.html
- "The Center for Operational Oceanographic Products and Services" is available at http://www.co-ops.nos.noaa.gov/
- "USGS Earthquakes Hazards Program" is available at http://www.neic.usgs.gov/
- "Volcano World" is available at http://volcano.und.nodak.edu/vw.html
- "WhaleNet" is available at http://whale.wheelock.edu

Problem-Based Learning Websites

- "Education Center on Computational Science and Engineering" is available at http://www.edcenter.sdsu.edu/projects/index.html
- "Genetic Science Learning Center" is available at http://gslc.genetics.utah.edu/teachers/
- "Plankton and Ocean Currents" is available at http://www.coolclassroom.org/cool_projects/lessons/physics_highschool/physicshighschool.html
- "Spring Acid Rain Watch" is available at http://www.qesn.meq.gouv.qc.ca/cc/acidrain/index.htm
- "The Gulf Stream Voyage" is available at http://www.k12science.org/curriculum/gulfstream/index.shtml