Virtual Learning Worlds as a Bridge between Arts and Humanities and Science and Technology

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Abstract

Science and technology, when applied to educational excellence, have become part of the arts and humanities of tomorrow. The interactive multimedia technology tools available to educators today provide an opportunity to build into the distance or traditional course through learning objects, highly interactive experiential exercises that allow the instructor and the student to obtain an accurate image of the student's level of understanding of the content throughout the course. The instructor can not only determine that a student does not understand some aspect of the content of the course, but may also determine exactly what part of the content the student fails to comprehend. Of more importance is the fact that students may also get an immediate and accurate map of their own mastery of the content. To create absorbing and successful traditional, blended, and online classes, a broader cooperative design structure that is as much art as technology is required. In this paper the concepts involved in the creation of course materials, through a cooperative partnership between Indiana University, ITT Educational Services, Inc. (the parent company for the 93 ITT Technical Institutes across the United States), Pearson Learning Solutions, and Arjuna Multimedia, are explored. They have resulted in a technological teaching environment in which sophisticated interactive computer technology may be incorporated into any classroom or distance course to provide the most effective learning experience. These techniques apply equally well in courses in arts and humanities and science and technology. Such tools as virtual worlds, laboratory simulations, game theory-based exercises, artificial intelligence systems, and intelligent tutors have been applied to several hundred courses in 17 countries with excellent results. The focus of this paper is on the pedagogical approaches considered and utilized in these cooperative course production partnerships.

Introduction

The use of technology in education has for the most part been plagued by unrealistic expectations and disappointing results. During the 1990s, teaching and learning were transformed by the increasing power of multimedia computers, broadband networks, and significant improvements in design and delivery of pedagogical content via electronic means. The industry went from CBT (Computer-Based Training) and rudimentary synchronous learning applications to sophisticated e-Learning platforms that combined the best of both. Many pundits argued that the days of traditional learning were numbered and that computers and the Internet would make teachers and classrooms obsolete. This did not happen. Though a variety of subjects can be effectively taught online, a computer model cannot qualitatively replicate the knowledge and experience of a great teacher.

However, as e-Learning matures, the many significant benefits of these technologies are beginning to be realized and find their place as an adjunct to traditional, pedagogical approaches. These first forays into network-delivered learning objects shattered the twin barriers of WHEN (Time) and WHERE (Space) students can access pedagogical experiences, thus effectively unchaining students from the requirement of being present in a specific location at a specific time in order to learn.

The necessities of our knowledge-based economy coupled with the exponential pace of change require us to constantly absorb new knowledge in order to remain competitive. Online learning provides a practical, cost-effective foundation for lifelong learning that is reshaping our notions of when and how we learn. “Learning on demand” provides education tailored to solve an immediate and specific need for learning that is time sensitive. Often used to refresh what one has learned or as a reference tool, instant access to learning has become both convenient and cost effective, allowing the student to minimize time away from work while simultaneously enhancing the skills, knowledge, and abilities required to adapt to the exigencies of our knowledge-based society.

One primary obstacle facing e-Learning is its inherent “one-size-fits-all” approach. Though we find similar problems within a classroom environment, the interaction with the teacher can help mitigate the effects of homogenized learning (often tailored to the lowest common denominator) by blending qualitative moments of one-on-one interaction during lessons or lectures. In order to fully reach its potential, e-Learning must begin addressing HOW individuals learn and adapt online instructional styles to the specific needs of the learner. Just as a good private teacher adapts his teaching methods to the individual student in question and over time gains understanding of which methods work for the specific individual, e-Learning technologies will need to become more “intelligent” by profiling students in real-time and delivering pedagogical content according to a series of fluid parameters that monitor student interaction with the learning content and present materials in a style that has the highest probability of success. By delivering learning in this way, content will be absorbed more quickly and retention of what was learned will be stronger, thereby enhancing the overall pedagogical outcome for the student.

Perhaps the most effective way to examine the role of technology in uniting the arts and humanities with science and technology is to focus on the high enrollment introductory courses known as "general education" courses in the U.S. These courses typically provide the foundations of knowledge for a variety of topic areas for students seeking degrees in all fields. The courses, for the most part, have high enrollments often exceeding 300 students, and low instructor-to-student ratios. The format is more transfer of content from instructor to student than traditional teaching, and the low levels of comprehension and satisfaction among the students in such courses reflect this. If we examine the ideal learning environment, as shown in Figure 1, we note that there are a number of components to successful learning, the most important of which is the relationship between the teacher and the student. The student interacts directly with peers and external resources such as libraries, but for the most part the content, textbook, and instruction are formulated and delivered to the student by the teacher, through learning objectives, activities, and assessments. In this idealized learning environment the teacher does not simply transfer specific content information to the student, but rather places the specific content in the course within the context of the greater subject matter. The successful teacher mediates the interaction between the content and the student and even moderates the manner in which the student utilizes the textbook.

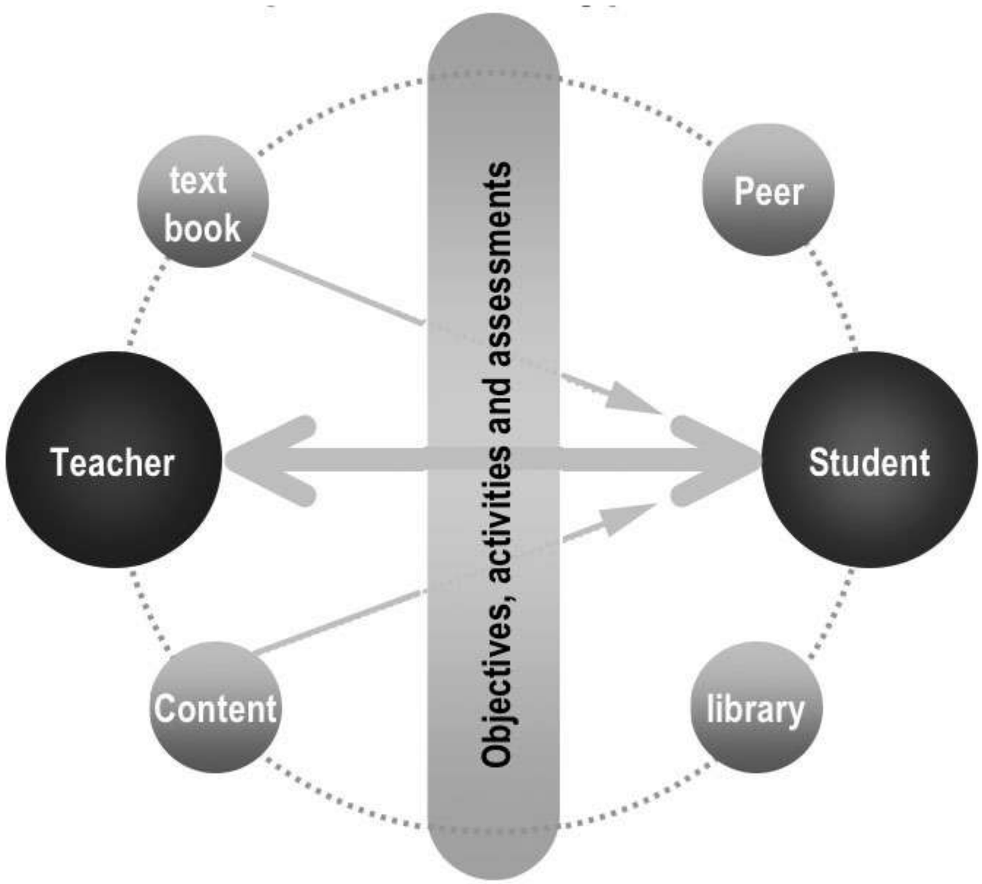

Figure 1. An idealized model of learning and interaction between the teacher and student is shown here.

In practice, the interaction between the teacher and student in large general education courses is restricted by the size of the class to simply the transfer of information from the teacher to the student through recitation and visual cues (Bhattacharya et al., 2007).

To succeed, technology must reproduce the teaching strategies of the successful teacher. Too often, however, technology-enhanced learning is hampered by a failure to deliver material in a manner consistent with the ways in which students learn and instructors teach best in traditional environments (Samoriski, 2002, and Bhattacharya et al., 2006). Successful teachers are successful because of the ways in which they mediate content and place the content within the context of the subject matter. It is not the specific content or images the successful teacher presents, but rather the manner in which they are presented and framed within the scope of the topic area. Excellent teachers teach by presenting the content and then providing the students with substantive opportunities to apply the content to real-world problems in an effort to promote critical thinking. This is a highly interactive process with much information being transmitted between the student and the instructor. The interchange between the instructor and the student helps the student build a knowledge base with the assistance of the instructor's experience and expertise in the topic area. The exact nature of the interchange is not predetermined and depends to a great extent on the creativity and breadth of experience of the instructor. The successful instructor adjusts the interaction with the student to the learning styles best suited to the student. How do we provide the learner with this important component of traditional classroom education in asynchronous distance education or technology-mediated traditional classes? Web-based instruction is rapidly becoming an important component of traditional education and we must adapt our instructional interaction styles to this medium. Our students now expect more interactive and immersive materials in Web-based learning than that typically provided in the traditional classroom or correspondence distance education (Samoriski, 2002).

Learning Objects and Learning Styles

Learning objects provide the online educator with the ability to recreate the successful learning strategies employed in the traditional class to enhance and enrich classroom interaction. In part this requires reproducing the interactions between instructor and student through rich, interactive learning environments in which the student may learn as much from failure as success in solving a particular problem. Learning objects are useful in online courses because they allow the student to (1) use the content learned in a particular part of a course, (2) demonstrate mastery of the content, (3) apply that knowledge to solving a problem, and (4) use the content in a critical thinking exercise that requires the student to place the content within the context of the larger course topic.

Although most educational researchers agree that individual differences in the ways in which students learn play a role in learning, there is little agreement on the nature of the different ways students learn. There is little agreement even on the terminology applied to ways in which students learn. Terms such as learning styles, cognitive styles, learning preference, learning strategies, and learning modalities are used to describe the same basic phenomenon—the manner in which students learn. Researchers use these terms almost interchangeably; however, learning style is the most commonly used term and will be used here. Learning style is generally accepted to be a student's existing learning strengths or preferred manner of learning (Kaplan & Kies, 1995).

Marineti (2003) and De Bello (1990), among others, have classified learning style as a subset of cognitive style. Others (Morse, 2003) feel that learning style encompasses cognitive style. The majority of researchers agree that individuals have different learning styles and that an individual modality of learning is not equally effective for all learners (Sims & Sims, 1995). Sadler-Smith (1997) identified four categories of learning styles: cognitive personality elements, information processing style, instructional preferences, and approaches to study.

A number of assessment tools and quantitative indices have been developed to define an individual's learning and cognitive styles. The early seminal work includes the Myers-Briggs Type Indicator, the Cognitive Preference Test (Messick, 1984), the Cognitive Style Profile (Kuckinskas, 1979), and the Learning Style Inventory (Kolb, 1976). More recent reviews of learning and cognitive styles include Dunning et al. (2003), Fennema (2003), and Patokorpi (2006). Collaborative learning is an important learning style that has so far been restricted for the most part to the traditional classroom, where it has been a successful learning strategy (Kurzel, 2006). Recent work by Dunning et al. (2003) and Hildebrandt (2003) has demonstrated that collaborative learning can be effectively executed in an online environment.

Perhaps the most commonly cited treatment of learning styles and learning skills is Bloom's Taxonomy (Bloom, 1956). Bloom created the taxonomy to categorize the learning outcomes that occur within educational settings. The taxonomy provides the instructor with a structure in which the categories of tests and activities can be related to the skills or learning styles that must be mastered in order to solve them. In a sense, the taxonomy is an inventory of skills and learning styles required to master content and acquire knowledge. Bloom's Taxonomy is described graphically in Table 1.

Table 1. Bloom's Taxonomy Applied to Learning Objects

Competence	Skill Demonstrated/ Learning Style
Knowledge	-Observation and Recall -Knowledge of Major Ideas, Dates, Places
Comprehension	-Understanding Information -Translate Knowledge into New Context
Application	-Use Information -Solve Problems Using Required Information -Use Methods, Concepts, and Theories in New Situations
Analysis	-Seeing Patterns -Organization of Parts -Identification of Parts
Synthesis	-Generalize from Given Facts -Predict, Draw Conclusions
Evaluation	-Compare and Discriminate between Ideas -Make Choices based on Reasoned Argument

(Modified from Bloom, 1956)

To learn more about Bloom's Taxonomy, go to http://www.arjunamultimedia.com/ort/ort.html and click the Bloom's Taxonomy link.

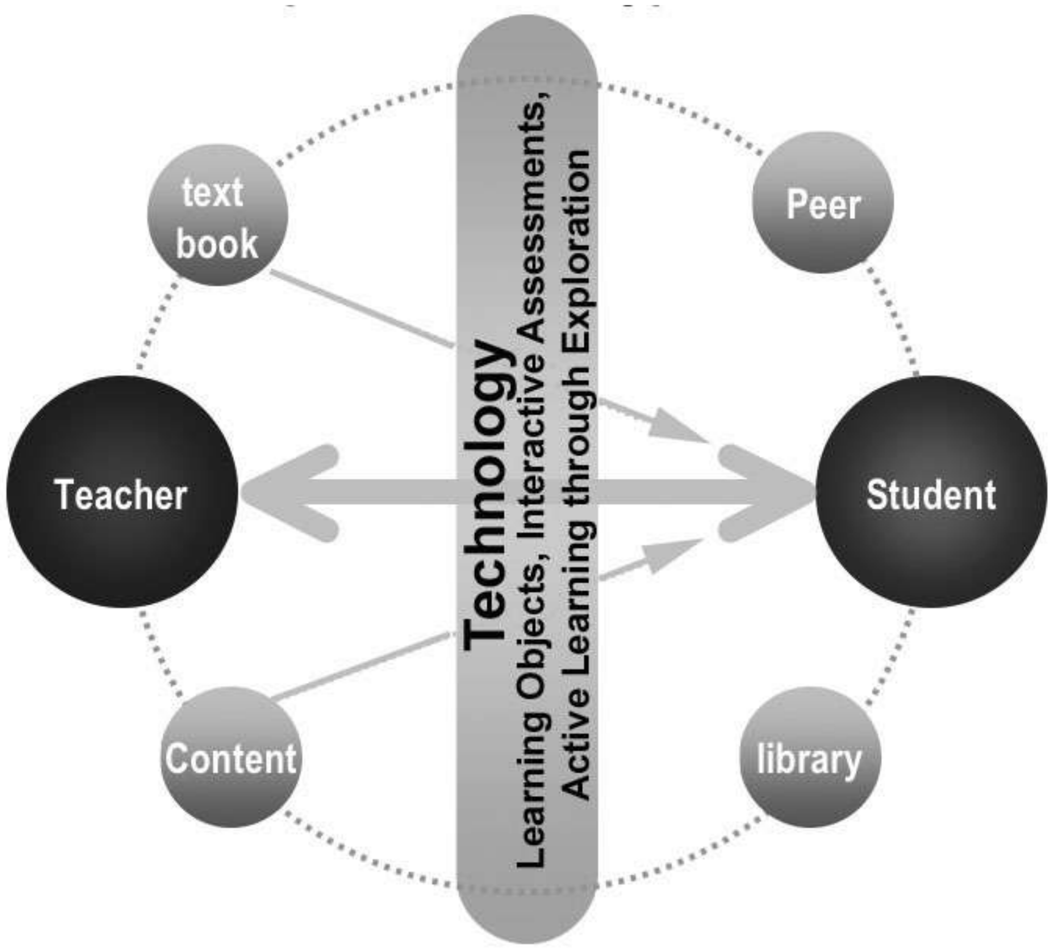

Figure 2. The altered dynamic of the interaction between teacher and student in technology-mediated courses is illustrated here.

Virtual Learning Worlds as Bridges

The advent of repurposeable learning object templates like TALON (Dunning et al., 2003) has allowed the course designer to create virtual learning worlds that to a great extent create the kind of learning bridges between content and learner that successful teachers build in small courses. Several pedagogic strategies will be reviewed, each representing different learning styles. In all cases, the learning objects come from general education courses designed for students not majoring in the subject. Most of the multimedia learning objects described here were created for a survey of science general education class at ITT Technical Institute and an introductory general education geology course fulfilling the science requirement for an arts and humanities undergraduate degree at Indiana University. The design model for the multimedia applications was developed jointly by ITT Educational Services, Inc. and Pearson Education, and the model is a critical component to the success of the course and learning objects.

Visual Learning and Exploration. Most students include visual learning as one of their preferred learning styles. In many cases, learning objects utilizing visual learning styles involve mapping or recreating an image that represents an important concept. This can be done with simple "click and drag" operations or other forms of recreating an image. Visual learning styles can also be implemented as higher level learning objects in which the student explores visual representations of data, situations, or structures and builds knowledge about a broader and more complex concept than is possible with the simple re-creation of an image. In the example shown in Figure 3, the evidence for plate tectonics is reviewed by the students in a survey of science course for non-science majors. The key to establishing the validity of plate tectonics is establishing that the plates we now observe on the surface of the earth were once part of a single "mega-continent" which has since broken apart into the current continental landmasses of the earth. There are a number of independent lines of evidence that show that the plates were once part of a single landmass. The first is simply that one can place the continental outlines together in a "best fit," like a jigsaw puzzle, with almost no overlap or gaps, to form a single landmass. This evidence in and of itself does not establish the validity of plate tectonics because there are other less satisfactory ways in which the continents can be placed in a single landmass. If, however, we look at the rocks and structures that are older than 200 million years and then place the continents together in the "best fit" configuration, these rocks and structures also fit together perfectly, as shown in Figure 3. Thus, the student discovers that there are multiple independent lines of evidence for the concept of plate tectonics. In Figure 3, the student is presented with the 200 million year old rocks and structures in the continents in their current positions (the globe on the left). Then, by clicking the 200 MYA button, the continents are moved together into their projected positions of 200 million years ago, as shown on the right globe, and the overlap of the structures and rocks is clearly shown.

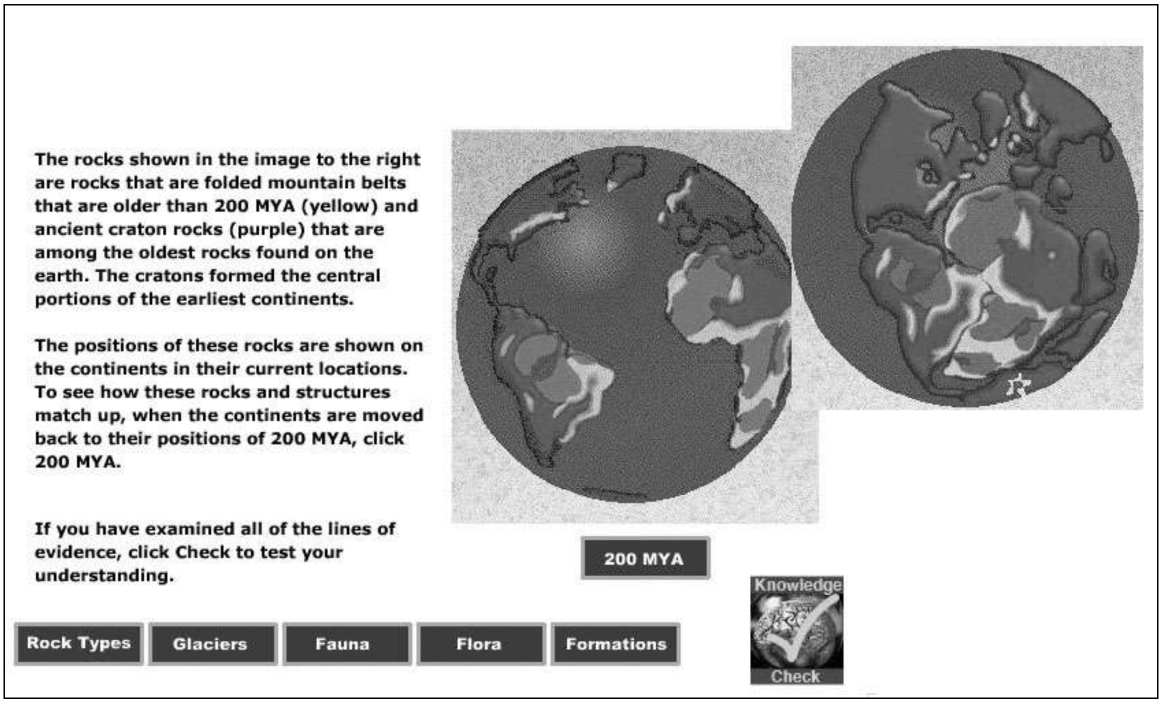

Figure 3. Exploration, visualization, and hypothesis building can be replicated in a learning object.

The student may also investigate in the same manner the overlap of glacial deposits, fauna, flora, and distinct rock formations (like coal deposits) from 200 million years ago and build the evidence for plate tectonics in much the same way it was historically developed by many geoscientists. Another benefit of this learning object is that those students who are not scientifically oriented get a glimpse of the scientific method and the ways in which scientific theories are developed. This application uses an approach that is more akin to the teaching strategies employed in the arts and humanities than in the sciences. Much science is taught by transferring specific information and organizational information to the student within a relatively narrow context. The rationale and historical context of the information transferred to the student is often not a part of conventional science education. In this learning object, an experiential and historical/story-telling approach is used. The student essentially learns about plate tectonics by exploring and interpreting in the same way the fathers of plate tectonics did throughout the history of the development of plate tectonics. After the student has explored the evidence fully, he can click the Knowledge Check button and test his understanding of what was covered in the learning objects by selecting correct statements, as shown in Figure 4.

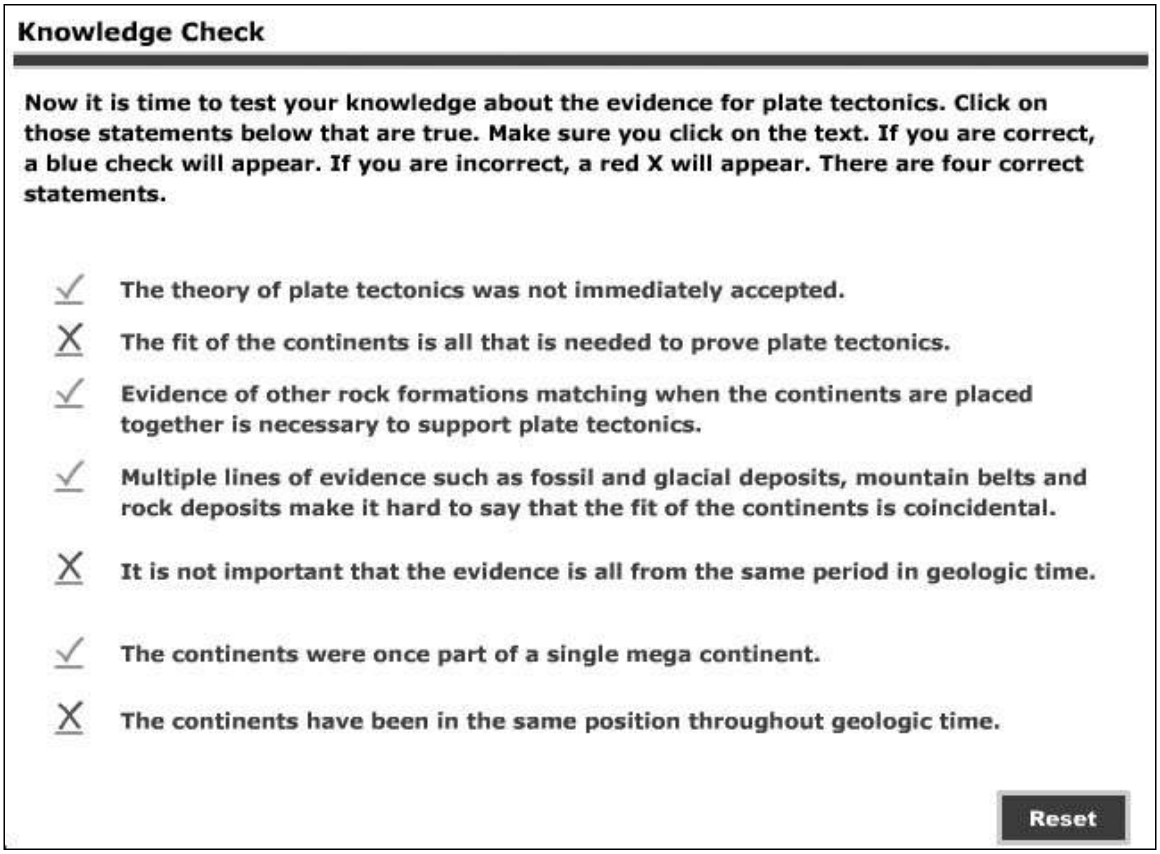

Figure 4. Assessment of basic comprehension can be incorporated into the learning object and allows the student insight into his mastery of the subject matter covered in the learning object.

To explore this learning object, go to http://www.arjunamultimedia.com/ort/ort.html and click the Visual Learning and Exploration link.

Measurement Skills. The general education student must learn to develop measurement and analysis skills, and these skills are not always accessible to students in large classes. The interaction between the teacher and student in small classrooms that helps the student master these skills must be recreated within the learning object in larger general education classes. In the example illustrated in Figure 5, humanities majors in a survey of science course learn first about the important parts of a wave, including amplitude, wavelength, and period. After exploring these features of waves, the student is given a sample wave and is asked to use draggable measurement scales to measure the amplitude, wavelength, and period of the wave, as shown in Figure 5. Once the measurements have been made, the student types the measured values into the boxes supplied and submits the answers. After entering the answers, the student clicks the SUBMIT button and receives immediate assessment. This learning object again approaches the concept of measurement from a slightly different perspective than is typically utilized in science education. More emphasis is placed on the nature of the parameters being measured and the nature of the measurement process, and less is placed on the measurement itself. If the same application were used in a science course, the learning object would begin with the actual measurement process and limit the coverage of the rationale and nature of the measurement.

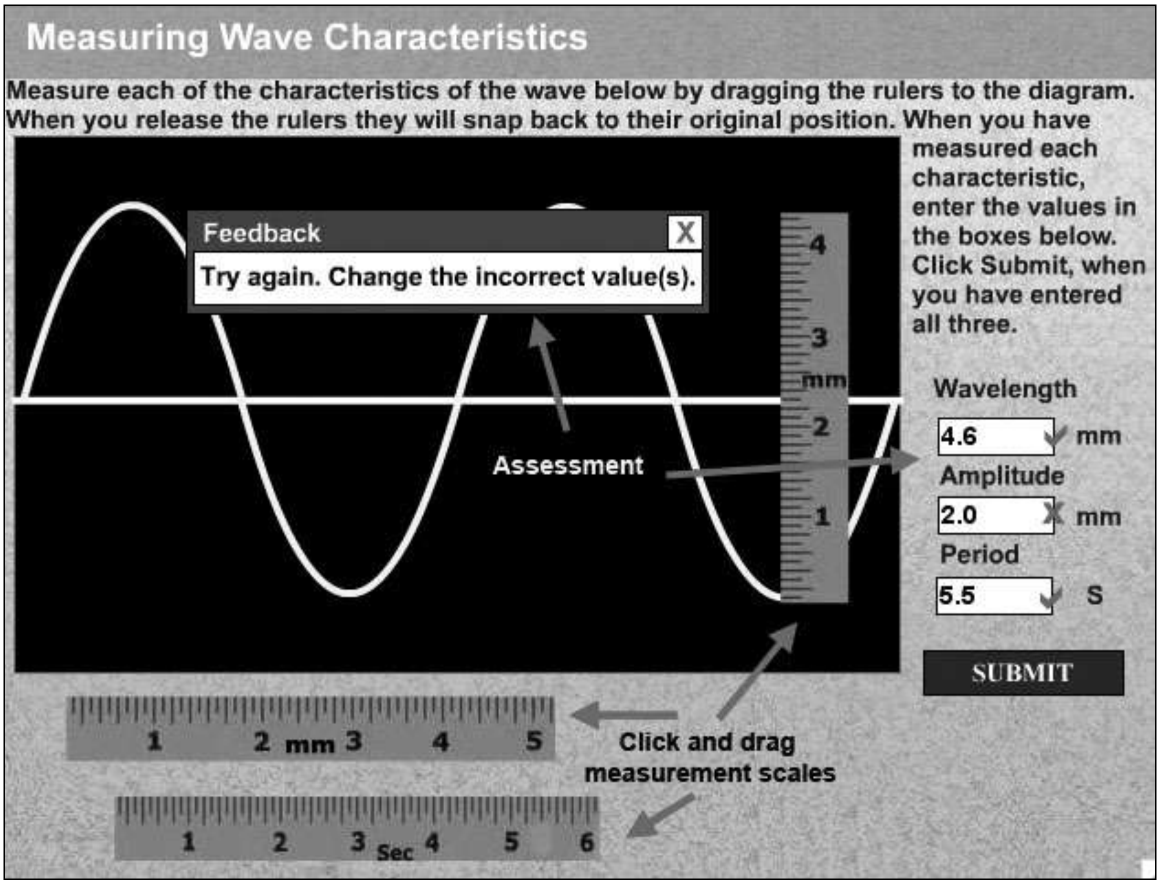

Figure 5. Measurement and analysis can be incorporated into the learning object.

To explore this learning object, go to http://www.arjunamultimedia.com/ort/ort.html and click the Measurement Skills link.

Complex Problems. Well-educated humanities and science majors will need, in their professional lives, to analyze complex problems with much quantitative and qualitative information that must be understood and placed within the correct context of the problem. In the problem illustrated in Figure 6, students in a public policy course must determine whether a proposed site for the creation of a chemical waste disposal facility is appropriate. To accomplish this task, the student must be able to analyze the important factors that affect the public, as shown in Figure 6. These factors include purely scientific factors, like the groundwater system, and social science factors, like the demography of the proposed site. The student is provided with a geologic map and cross-sections of the area to be analyzed and the geologic column (the layering of rocks beneath the surface). The student may access each of the factors to be considered by pressing the appropriate button, as shown in Figure 6.

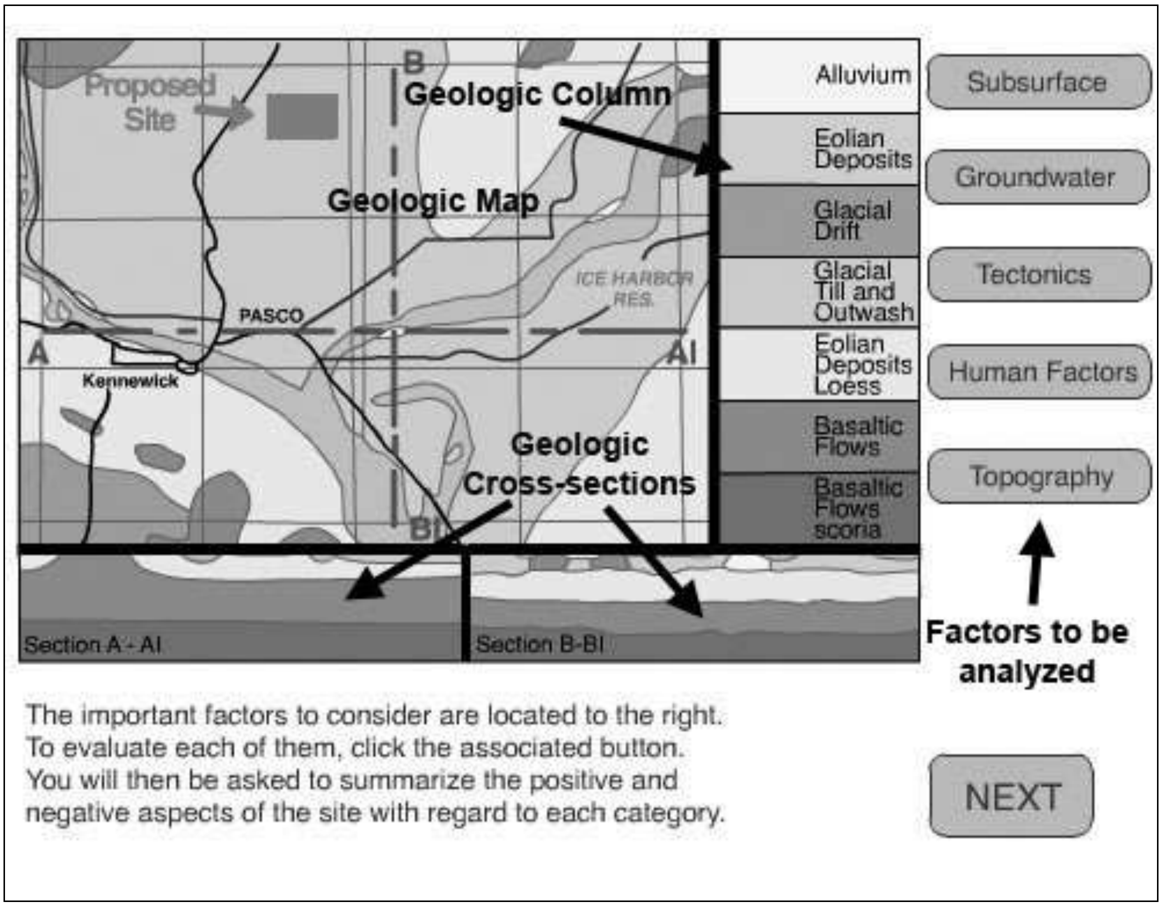

Figure 6. Complex problems can be recreated in the form of learning objects.

When the student selects a factor to be considered in selecting the site for the chemical waste facility, an array of information and additional data pertaining to that factor is presented. The student must decide whether each supports the placement of the facility at the proposed site by clicking the + column or – column, as shown in Figure 7. The subsurface in this case is analyzed with a combination of data in the form of the subsurface cross-section shown in Figure 7 and additional important information regarding the subsurface of the site.

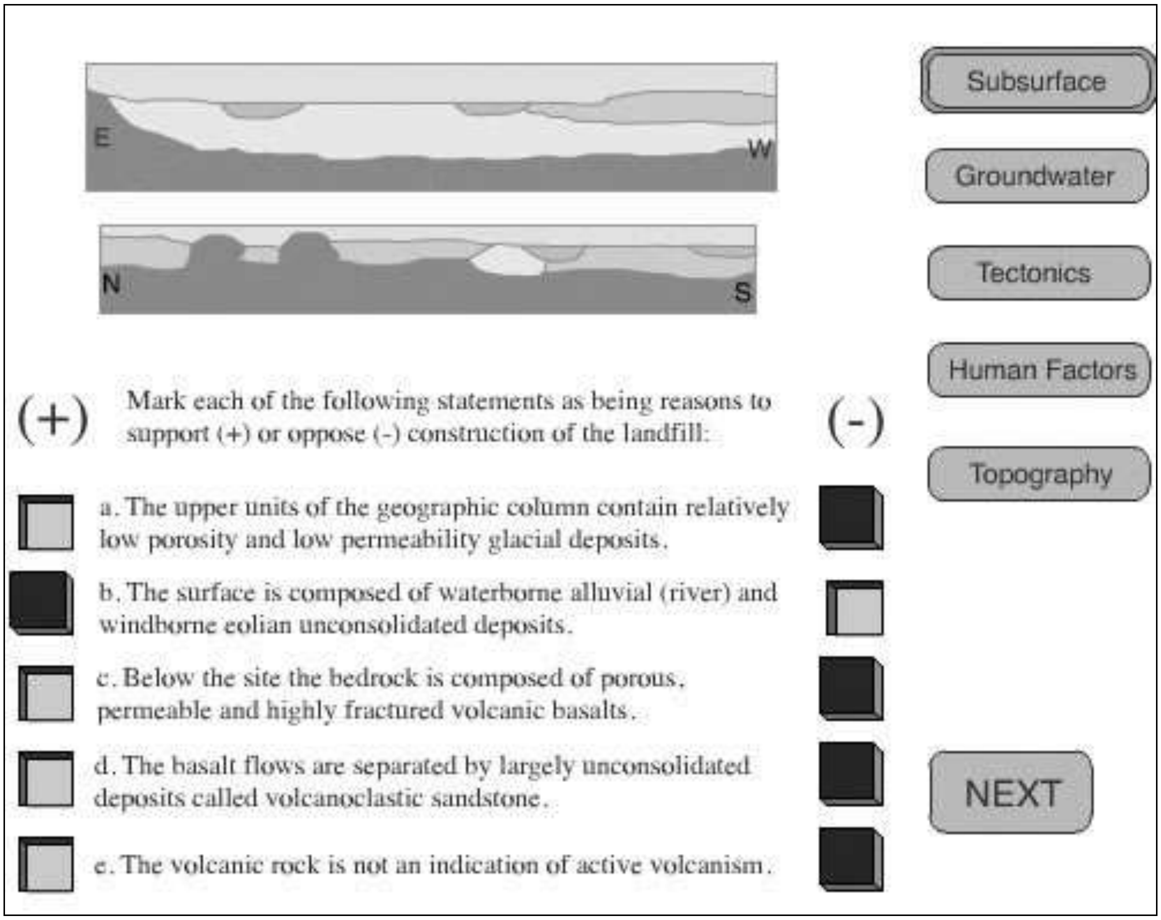

Figure 7. Analyzing the subsurface of the proposed chemical waste site is part of this case study learning object.

The analysis and evaluation of each of the factors is then placed in a repository of positive and negative factors, much like a notebook kept by the student as he navigates through the problem. When the student has evaluated all of the important factors, he can access this notebook of positive and negative factors, as shown in Figure 8. Interactive multimedia learning objects can be created that replicate real problems with accurate levels of complexity and allow the student to "learn by doing."

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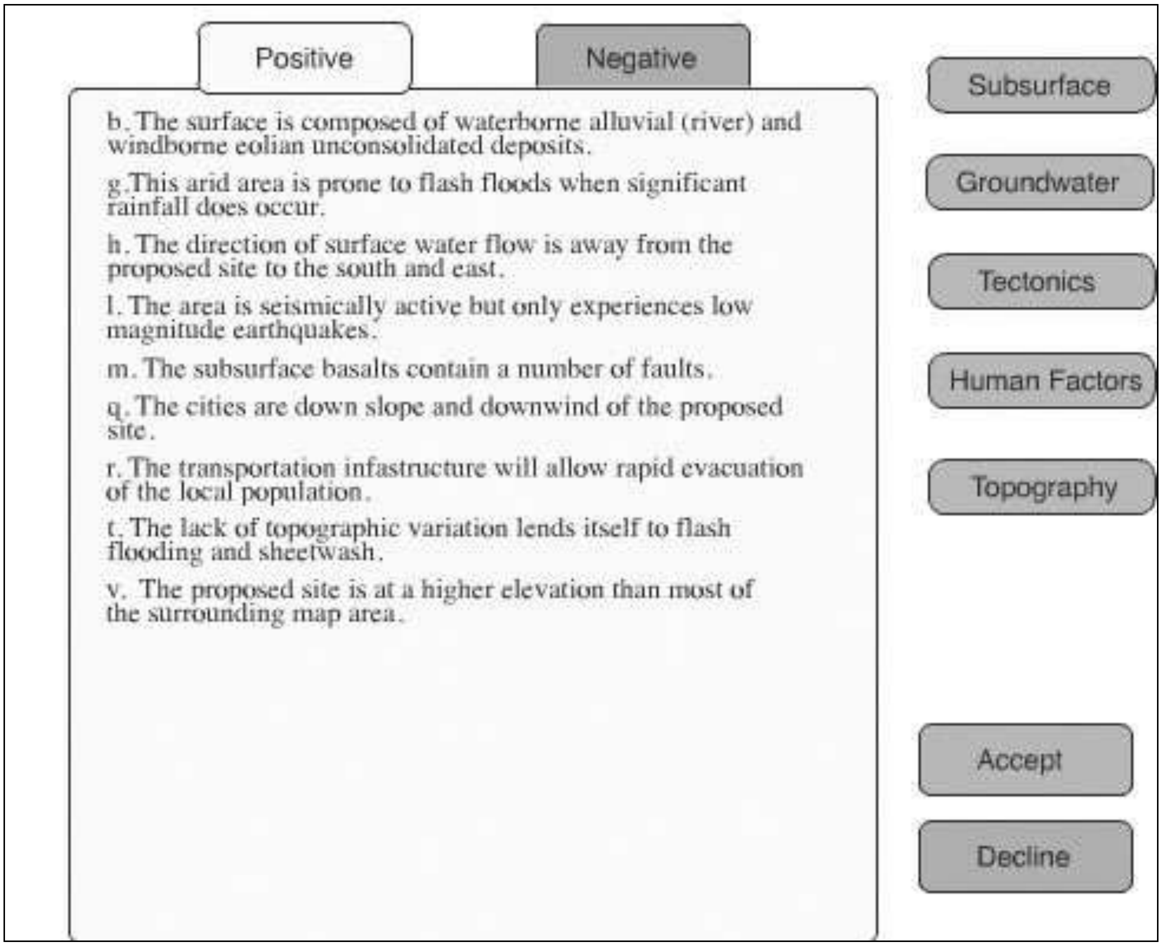

Figure 8. The positive factors selected by the student presented in "notebook" form are shown. After the student has analyzed all of the positive and negative factors he has selected, he must accept or decline the site by clicking the appropriate button.

At the end of the problem the student may check the items selected as positives and negatives and find out if the selections were correct. Students occasionally get the correct answers for the wrong reasons, and this feature provides the student with input on whether his reasoning was correct.

This application was designed to help the student understand the nature of the scientific problem and the interplay between public policy and the specific problem at hand. It is presented in much the same way that arts and humanities instructors develop a particular theme within the broad context of the greater subject matter, as opposed to the typical science education approach of addressing the specific problem to be solved.

To explore this learning object, go to http://www.arjunamultimedia.com/ort/ort.html and click the Complex Problems link.

Time Revealed Scenario. Problem solving is an important way in which we establish mastery over content by using that content to solve a real-world problem. The time revealed scenario tool allows a student to work through a problem by making decisions based on content mastery and briefings in a time-layered approach. Each time layer represents a stage in a process that occurs over a period of time and is driven by the previous decisions of the student. The student is first presented with a problem and information that requires a decision on the best course of action to solve a problem, as shown in Figure 9.

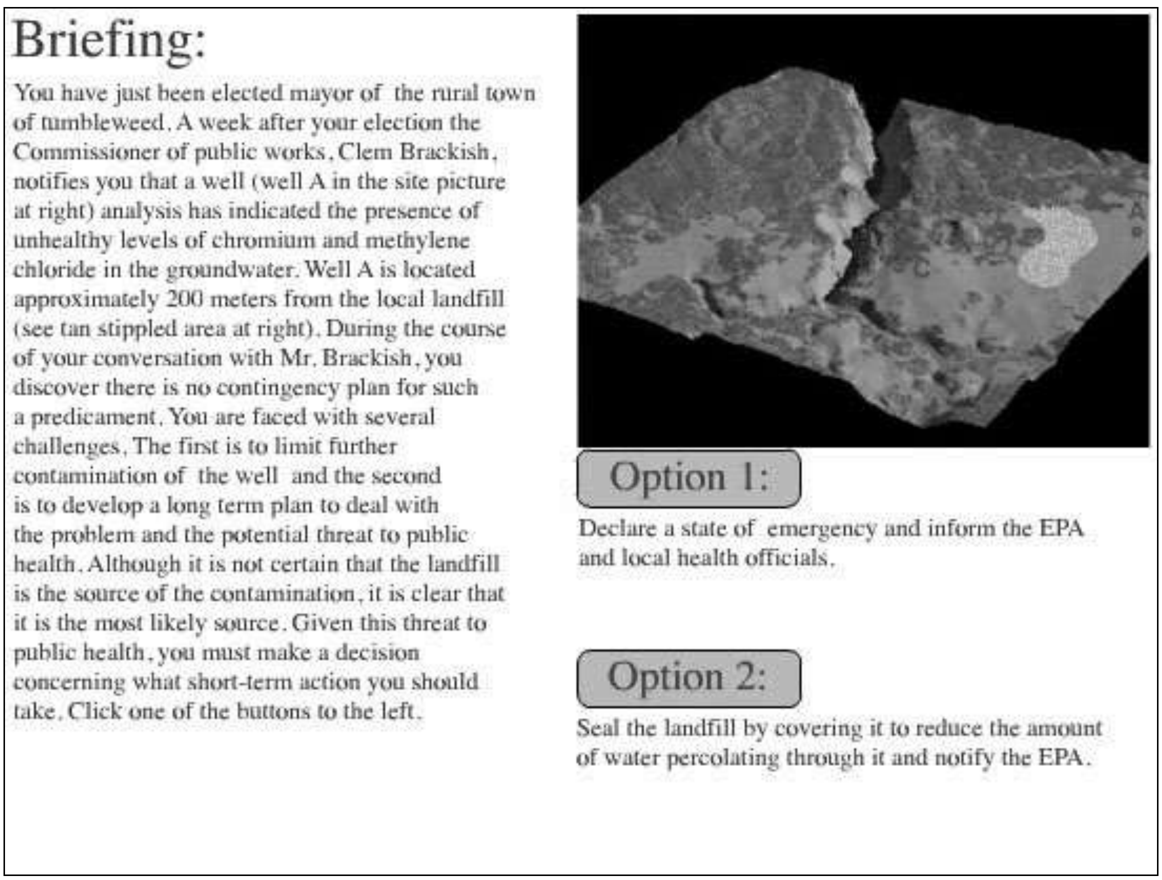

Figure 9. The time revealed scenario problem provides the student with a sequential approach to problem solving.

Once the student has selected an option in the first level of the problem, an updated briefing is provided that reflects the effects of the decision just made and an update of the problem as a whole. In a sense, it represents the normal passage of time involved in addressing a problem in the real world. The student is then asked to make another decision to push towards a solution of the initial problem, as shown in Figure 10.

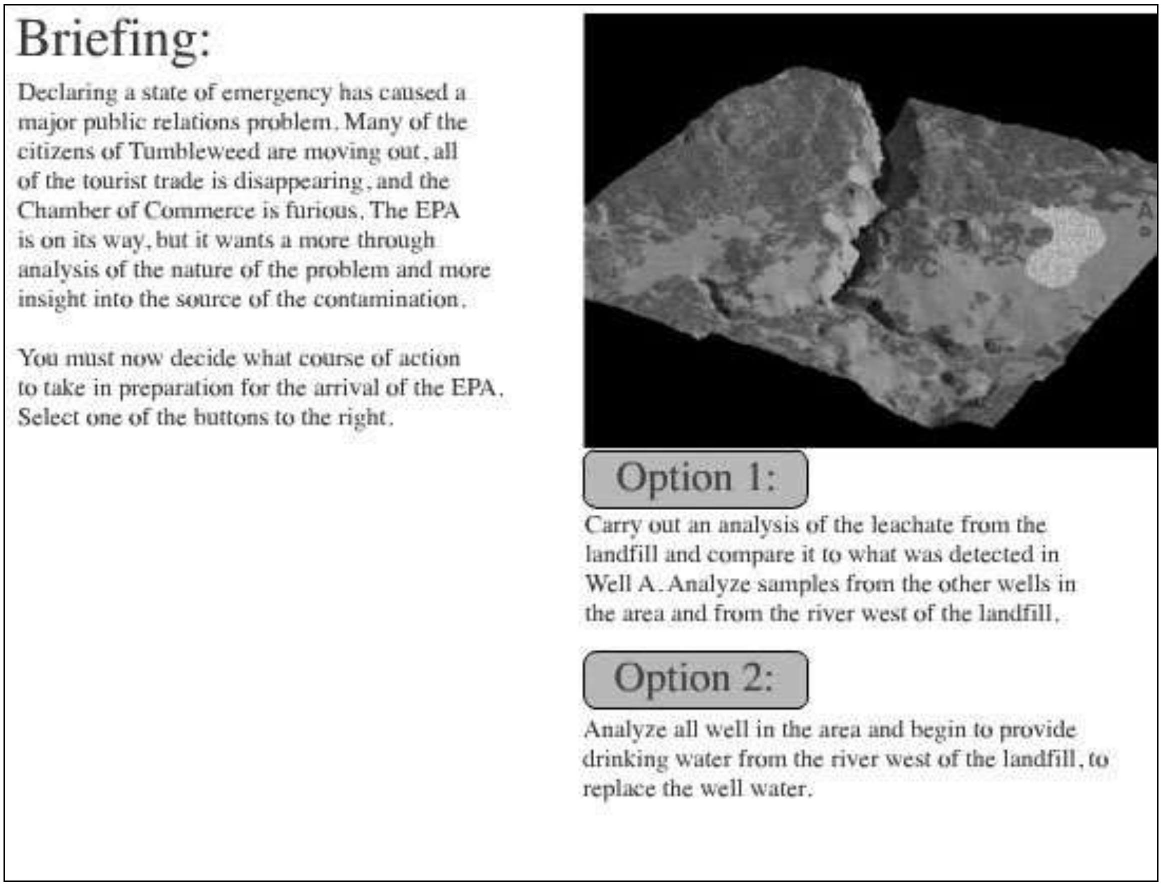

Figure 10. The second phase of the problem, reflecting the decision made by the student in the first phase, is presented along with the next decision to be made.

Eventually, as the student continues to drive the problem forward by making decisions at each stage, the problem solution or outcome is achieved. As is the case in real problems, there can be numerous outcomes depending on the decisions made by the student at each stage of the problem. The outcomes represent a spectrum of correct and incorrect strategies, and the student may learn as much from an unsuccessful strategy as a successful one. The student may also attempt the problem several times to determine how different problem-solving strategies work. The template used to make this problem can be configured with a wide variety of decision-making levels and number of decisions to be made at each level. A typical outcome is shown in Figure 11.

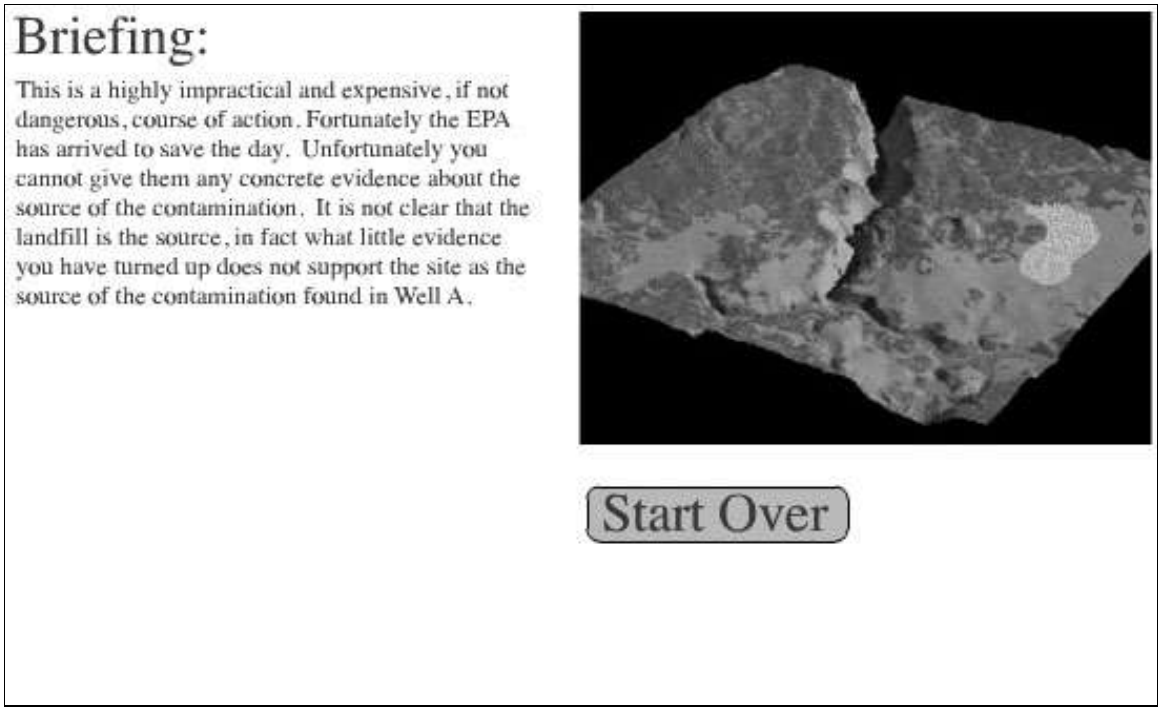

Figure 11. The outcome of the time revealed scenario problem gives the student a brief explanation of how well their choices worked in the given scenario.

To explore this learning object, go to http://www.arjunamultimedia.com/ort/ort.html and click the Time Revealed Scenario link.

Future Trends

The development of a set of reprogrammable learning objects, like TALON (Dunning et al., 2003), that are defined by and designed for some of the important styles of learning and teaching creates a number of possible opportunities for the improvement of traditional classroom education and distance education.

Teachers as Instructional Designers. One of the greatest challenges and opportunities is the involvement of the instructor in the creation of learning objects. The template system allows an instructor to create learning objects on a discrete body of content in several learning modalities and allows the student to learn in the modality best suited to his or her style of learning. Several hundred elementary and secondary schoolteachers in Malaysia are currently using TALON templates to create their own learning objects for their classes. In many cases, especially in higher education, it may be more practical for the instructor to simply use the templates to design a learning object and leave the actual programming to a staff programmer. The templates do allow the programming to be done rapidly because no source code must be written. The teacher must simply select one of the more than seventy templates that match the teaching style the instructor wishes to use, and the content can simply be inserted into the template.

Artificial Intelligence and Learning Objects. When combined with artificial intelligence software, the entire set of learning objects for a course may be tailored to the learner's style of learning in order to ensure mastery of content. When a student encounters the first block of content, several learning objects in variable modes of learning are presented. The results of the student's attempts are then evaluated in real-time by an artificial intelligence-based assessment tool and a profile is built for that student. The learning objects for the next content area are then presented in the order of learning modalities best suited to the student's learning style. The assessment tool then updates the profile and reconfigures the order of learning objects in the various learning styles for the next content area. By the completion of the course, the student will not only have mastered the content in learning modalities best suited to his or her learning style, but will also have strengthened his or her skills in the other learning styles. It is possible that each student in such a class might follow a unique pathway through the course based on the constantly updated student profile.

To explore this learning object, go to http://www.arjunamultimedia.com/ort/ort.html and click the Artificial Intelligence link.

Matching Teaching Styles to Student Lifestyles. Student lifestyles and use of technology have changed rapidly during the last decade. In North America and Europe over 95% of college students have access to computers and more than 70% own a computer. In the United States more than half of the college students have an IPOD or similar MP3 player. Most university-level students have spent considerable time playing video games. With this in mind, the use of such MP3 technologies and game-based formats makes sense. Podcasts with or without video are becoming common in undergraduate courses and are ubiquitous in MBA programs. Many MBA students who are part-time students listen to Podcasts from their MBA classes on their way to work. Couching rigorous instruction in game-based format can also be an effective way of reaching students, although this approach has met with some resistance among faculty. In both cases, educational exercises are simply embedded into student lifestyles and technologies, without diminishing the content or delivery.

To explore this learning object, go to http://www.arjunamultimedia.com/ort/ort.html and click the Game-based Exercises and Podcasts links.

Conclusions

It is clear that the traditional model of instructors teaching small classes with much personal interaction with the students is becoming rare at the general education level (100 and 200 level classes) given the economic exigencies of higher education. The new rubric described in this paper, in which technology is used to provide the kind of substantive interaction that good teachers supply in small classrooms, is appealing. The critical issue is whether this approach results in meaningful learning, analogous to the traditional classroom.

Those courses at ITT Technical Institute that employ these types of learning objects in online courses experience higher retention and better student satisfaction than those courses that do not contain them. Student surveys carried out by outside consultants also established the students' preference for material supplemented by multimedia learning objects. Reduction of time on task, by using learning objects, was also observed by the consultants. Some of the learning objects included here are part of a traditional survey of science course that will be structured in a fashion similar to blended education. The traditional laboratory and lecture in class will be supplemented by guided multimedia instruction provided to the student online and in a CD-ROM. Geology 116 (Our Planet and its Future) at Indiana University provides an interesting case study. This course is a typical general education science requirement for non-science majors. When the course was converted from a traditional class to a course blending significant interactive multimedia on a Web site, the retention, attendance, and enrollment all increased significantly. In the last semester this course was taught in the traditional format it had an enrollment of 38, had 78% retention, and had an average of 77.1% on a standardized earth science test created from a test bank. After three years in the technology-mediated format, the enrollment is 112 (limited by the size of the classroom) with 98% retention, and an average of 84.3% on the standardized test. The waiting list for the course (after the class limit is reached) is usually over 20. Similar results have been reported as anecdotes, but rigorous statistical information on retention, enrollment, and attendance is not always available.

To see the next generation of the G-116 blended learning course, go to http://www.indiana.edu/~g103/plate/plate.html.

The approach clearly worked in G-116, but it has had more limited success on a broader basis. In most cases it fails because of financial reasons. The budgets provided for multimedia are limited and most universities do not employ learning object templates, restricting the interactive multimedia to simple and repetitive true-false and click-and-drag multimedia exercises that rapidly become tedious for the student. One promising new opportunity occurs when publishers and universities form partnerships to create multimedia supplements and customized textbooks for large general education classes. ITT Educational Services, Inc., a proprietary institution of higher education, and Pearson Learning Solutions have formed such a partnership with Arjuna Multimedia providing multimedia learning objects. The retention in these online and traditional courses is substantially above the national average so far, although only a few courses have been converted for enough semesters to determine the retention with statistical confidence. The student evaluations at ITT Educational Services, Inc. have been far more enthusiastic for these new courses than the original courses. On the basis of the experience described in this paper, it would seem that partnerships such as this provide a financially reasonable model for creating rich interactive general education courses.

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