An Investigation of a Web-Based Learning Environment Designed to Enhance the Motivation and Achievement of Students in Learning Difficult Mental Models in High School Science

Shiang-Kwei Wang, Chia-chi Yang
Department of Instructional Technology
University of Georgia
United States
E-mail skwang@arches.uga.edu, chiayang@directvinternet.com

Abstract: A high school science teacher reported that the students have motivation and learning problems to understand the concept of fossilization. Working with the science teacher, a Web-Based Learning Environment (Web-LE) has been designed by a group of students in the Department of Instructional Technology at University of Georgia to enhance and sustain the motivation of learners in the context of secondary science education. The cognitive tool approach is employed to design the Web-LE to enhance the learners' cognition toward the scientific concept of fossilization. Several strategies for increasing students' intrinsic motivation will be involved in the Web-LE design. The goal is to find the practical approaches to design the online fossil course that should be shored up by the instructional theories including cooperative learning and the motivational theories. The high school teachers can use the Web-LE to aid the science subject instruction without purchasing software.

Introduction

This Web-Based Learning Environment (Web-LE) is being designed to explore the unique WWW features and utilize these elements to enhance and sustain the motivation of online learners in the context of secondary science education. The goal is to find the practical approaches to design the online fossilization course that should be shored up by the instructional theories including cooperative learning and the motivational theories. The high school teachers can use the Web-LE to aid the science subject instruction without purchasing software.

Information scientists estimate that the World Wide Web (WWW) now has nearly one billion pages, and the WWW continues to grow at a rapid pace. Although many web sites may be inaccurate, misleading, biased, or even criminal in nature, there are still millions of pages that high school students and their teachers can access to enhance teaching and learning. Unfortunately, while there is enthusiasm in many quarters about the integration of the WWW into education, there appears to be a lack of substantive thinking about the goals, pedagogical dimensions, and outcomes of using the web in secondary education. There is a strong need to develop and test new models of the factors that will enable the effective use of the WWW in high schools. One such model is based upon the concept of the WWW as a "cognitive tool" (Reeves & Reeves, 1997). Cognitive tools refer to technologies that enhance our cognitive powers during thinking, problem-solving, and learning (Jonassen & Reeves, 1996). Using the WWW as a cognitive tool, students tackle difficult problems and complex tasks, organize unique knowledge representations, and share what they have learned with others for analysis, critique, and revision.

The purpose of this research is twofold. First, the features of the WWW that increase and sustain the motivation of online learners will be identified through interviews with students, teachers, and experts. Second, using development research processes, a fossilization Web-based Learning Environment (Web-LE) that incorporates these motivational features will be designed, developed, and tested in the context of high school science.

Background

The primary setting was a local private school located in a small city in northern Georgia. This school is equipped with well-organized computer technology including computer labs and wireless network. Students and teachers are used to the computer environment and equipped with high computer literacy. This research adopts purposive sampling method based on the specific purposes to work closely with the science teacher and students in a local school to promote learners' motivation and learning achievement. The participants are one male teacher and 16 10th grade students. The teacher is an experienced science instructor. The teacher encountered problems to convey the concept of fossilization to students, and has difficulty to motivate students.

The science teacher reported that the students have problems to understand the concept of fossilization. Fossilization is a result of complex combination of organism, ecological and physical burial. The fossil would be formed only under the correct situation. Students have to understand that how and why ecological and physical burial influence fossilization. The teacher couldn't find accurate or useful materials to help students visualize the process of fossilization. Some web sites introducing the fossilization contain only still images, pictures and texts, and the representations are not realistic enough or accurate to be employed in the classroom. The science teacher needs a tool that is realistic and accurate to explain the fossilization and provides opportunities for learners to consider the potential combinations of different decision. The learner will be able to identify situations that will cause fossilization. After evaluating the current available computer-learning environment, a Web-LE has been decided to be employed to carry the instructional contents.

Employing Web-LE as the cognitive tool

Owston (1997) indicated that the key to promoting improved learning with the Web appears to lie in how effectively the medium is exploit d in the teaching and learning situation. The standard online tools mentioned above offer restricted choice to instructors seeking to offer experiences with complexity and dynamics of classroom experiences, and we need new tools to enable a variety of interactions (Hughes & Hewson, 1998). The advent of online interactive learning system enhances the interaction in the learning environment. Participants can interact with other participants to discuss the questions and concepts. With authoring tool (e.g., Macromedia shockwave, Flash, Authorware, JAVA), instructor can design the synchronous or asynchronous activities based on different goals and tasks. The features of open environment and immediate communication can be embedded in the application to enable collaborative learning strategies. The ability of these tools to carry interactive multimedia contents support design of situated learning strategies by simulation, problem solving or authentic activities (Leflore, 2000). The features of dynamic pages allow learners interact with contents directly to process the information individually. Learners will be benefited by the delivery of information with appropriate instructional design instead of presenting information in hypermedia structure and multimedia contents (e.g., streaming audio and video). Web pages can carry multimedia and access to the open environment. Learners can interact with content with pages (browsing, filling questionnaire…), and the level of interactivity depends on how the designers design the web pages. With the features that the WWW provide, it makes Web the appropriate tool to carry the instructional contents.

Several doctoral and master students have been working together to design the fossilization Web-LE in the Department of Instructional Technology at University of Georgia under the guidance of two faculty members. The science teacher is the subject expert, who works closely with the team to verify the accuracy of the contents, identifies the educational problems and provides feasible instructional strategies. The system is developed by Macromedia Flash and combines with the online database with ASP and MS Access.

Instructional design strategies

Several strategies for increasing students' intrinsic motivation will be involved in the Web-LE. First, Lepper and Hodell's (1989) four characteristics of tasks that promote individual intrinsic motivation will be integrated into the instructional design.

1. *Challenge:* Engaging with the activities that challenge learners' abilities may enhance the intrinsic motivation. The premise is that the challenges of activity and skills of learner should be matched.

2. *Curiosity:* Curiosity can be achieved by using the technical events to attract the learner's attention. Highlighting incompleteness or inconsistency is one technique to arouse the curiosity. Through the provision of unpredictable or random events may motivate learners to continue the learning processes.
3. *Control:* Learners' intrinsic motivation may be enhanced if the activities can provide a sense of control over their learning performance.
4. *Fantasy:* Fantasy environment is defined by Malone and Lepper (1983) as one that evokes mental images of physical or social situations not actually present

Second, Web has the capabilities to facilitate the communications among participants, and this feature provides the opportunities to carry out the cooperative and competitive strategies, whereas the open environment feature enables learners to publish their products or achievement and have people recognize their performance. The design of Web-LE will integrate the cooperation, competition and recognition strategies to facilitate collaborative learning pedagogy and stimulate interpersonal intrinsic motivation (Malone and Lepper, 1983).

The third strategy is to integrate multimedia objects into learning context. Learning with multimedia provides an effective alternative instructional strategy (Mathewson, 1999). From the motivational perspective, using medium to assist instruction indeed enhance learners' interest (Freeley, 1982; Kramarski & Feldman, 2000). Computer enables visualization of scientific concept and Internet enhances interaction among learners. The multimedia objects will be employed to represent the fossil concepts to enhance the intrinsic motivation.

Overviews of the system

Instructional content

How does a living thing become a fossil? Not all parts of animals and plants become fossilized. After completing learning the concept of fossilization with this cognitive tool, students will be able to identify conditions necessary for fossilization and construct possible scenarios for formation of fossils by manipulating the variables in the simulated processes. Fossilization is a rare event. The chances of a given individual being preserved in the fossil record are very small. Whether a living thing could become a fossil depends on three categories of conditions (organism, ecological status and physical burial), if an organism has hard part or not, if an organism gets buried quickly and the ecological situation, where an organism dies. It's only possible that a living thing can become a fossil when these three conditions are met.

System function

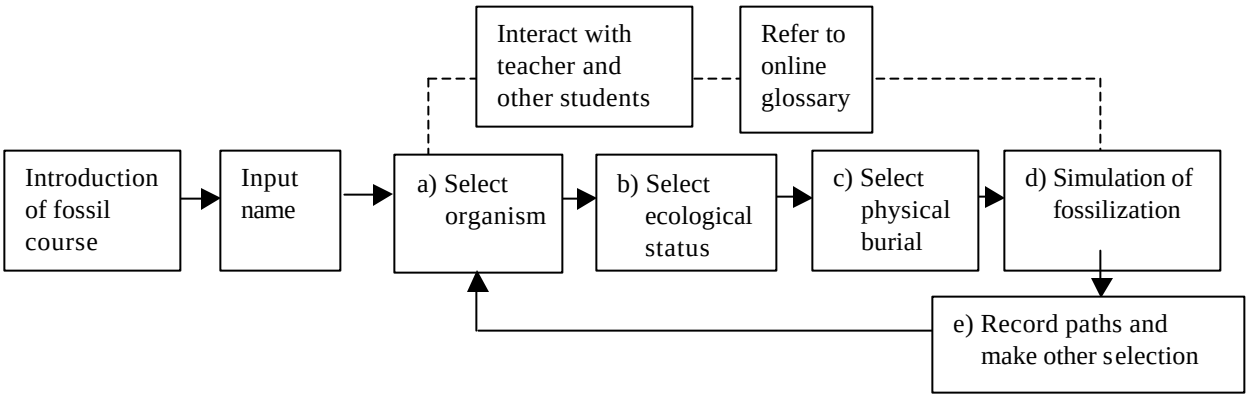


Figure 1: Flow chart of the fossil Web-LE

Figure 1 is the flow chart of the fossilization Web-LE. When entering the Web-LE, learners will see the instructional page to explain the learning objectives and goals of the fossil unit. Learners have to input names and login into the system. In screen a, learners can select different organism to observe the fossilization process. The dinosaur is the only available organism in the prototype. The description of this organism is placed under the screen (Screen 1). Learners can access to the online glossary to look up information if they have any questions. In screen b, they need to select the ecological status (Screen 2). In screen c, learners need to select physical burial. The combination of three decisions can decide whether the fossil will be developed. Simulation of fossilization begins when the decision has been made. The system will record paths that learners just made and help learners to identify the learning progress (Screen 3). After experiencing all twelve possible paths, learners will be able to identify the situations that can create fossils (online assessment).

The complete twelve possible combination including:

1. Organism
2. Ecological (3 conditions): temperate rainforest, tropical rainforest and tropical mountains
3. Physical burial (6 conditions): weathering, ashfall, lava flow, pyroclastic, flood and swamp mud burial.

Learners can assess to online glossary to look up information about these conditions. With the communication tools that the Web-LE provides, learners can send e-mail to other learners and teacher. They can discuss questions with the bulletin board.

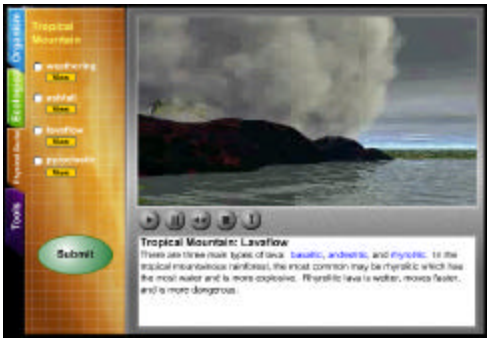
Media development

The primary audience is high school students who appeal to realistic graphics and animation. The science teacher also requests for the realistic representation of the fossilization process. Several endeavors are made to achieve the requirement. Referring the accurate images, the dinosaur is developed with accurate proportion and color. 3D software is used to develop the realistic landscapes and objects including ancient plants, volcano, lake and fossils. Macromedia Flash is the primary authoring tool because of its ability of integrating multimedia and the capability of optimizing media to enhance the speed of transmission.

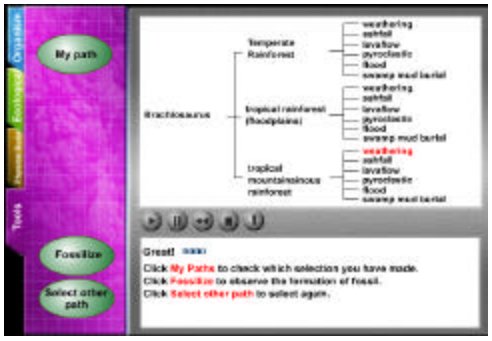
Screens example

Screen 1: Select organism

Screen 2: Select ecological status



Screen 3: Begin simulation of fossilization



Screen 4: Use "my path" to record selections

Learners need to select organism in Screen 1. The description of this organism will appear in the text area. Learners should continue to select ecological (Screen 2) and physical burial conditions. When learners click "submit" button, the simulation of fossilization will begin. An animation will appear to depict the procedures of fossilization. For instance, in Screen 3, learner chooses combination of " Brachiosaurus", "Tropical Mountain" and "Lava Flow". When simulation begins, the volcano explodes and the lava catches up the dinosaur to mantle its body. The fossil will be formed in this situation. In Screen 4, learners can assess to the communication tools (e-mail and discussion board). The function of "my paths" will record the paths that the learners have made and identify their learning progress.

Validation

The formative evaluation strategy is employed to make sure the content is accurate. The subject expert reviews the contents once a week and provides suggestion constantly. After the production is completed, the participants will be formed into one control group and one treatment group. Several instruments will be employed to exam the effects of the Web-LE on motivation, science and learning with Web-LE. The following interview with teachers and treatment group students will be conducted to probe their suggestions toward the Web-LE.

Expected Results

The expected results include: 1) effect of Web-LE on learning is significant difference between the control and treatment groups, 2) learners' motivation toward learning science with Web-LE is significant difference between the control and treatment groups, 3) the previous two results can confirm the usefulness of the pedagogies and identify the motivational indicators, 4) identify the mental model of online learners. The Web-LE will be released online and all teachers and learners who are studying the similar unit can use it as a learning resource.

Future work

The fossil Web-LE contains twelve paths and each of them needs to be completed by March 2002. The online database is under development to record and preserve users information. We're developing the communication tools including e-mail and bulletin board to enable the interaction among participants. The science subject expert is helping us to design the glossary pages for learners to refer to. The glossary pages contain multimedia explanation about the units of fossilization (for instance, the various images of fossils and video clips of reconstructing fossils). The fossil project is one unit of the entire Geology and Ecology course in the school. The URL of the Geology and Ecology course is: http://128.192.78.9/science. Other units (geological time, radio dating, volcano and continental drift) will be designed after the fossil project to expand the web-site into a learning resource for science class in high school. The URL of the fossil project is http://128.192.78.9/science/fossil (the permanent URL will be activated after June 2002: http://www.itstudio.net/fossil).

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Acknowledgements

The fossilization Web-LE is developed by Shiang-Kwei Wang, Chia-chi Yang, Wan-Ting Huang, Beaumie Kim, and Dr. Hill under Dr. Reeves and Dr. Hill's supervise. We appreciate Jack Kridler’s contribution to this project as a subject expert.