WEB-BASED MODULES FOR HIGH SCHOOL TECHNOLOGY LITERACY ENHANCEMENT – A UNIVERSITY/HIGH SCHOOL COOPERATIVE PROJECT

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***Abstract* ¾** *The web-based technology education (Web-Tech) modules program is a National Science Foundation (NSF) supported program for students in grades 9 to 12. The overall objective of the program is to provide a web-based multimedia-learning environment for students to learn and be educated to be technology literate persons. A total of eleven Web-Tech modules will be available to students; one for each of the first four chapters (Nature of Technology, Technology and Society, Design, and Abilities in a Technology World) and seven modules for the seven technologies in the chapter on the Designed World.*

Rapid technological changes and global economic competitive environment make it imperative to equip all students in K-12 grades with skills that go beyond the such basic skills as in reading, writing, mathematics, science and social studies. The recent publication of the Standards for Technological Literacy: Content for the Study of Technology by the International Technology Education Association (ITEA) mark a well-defined challenge for technology education. The standards provide an important basis for the development curricula and instructional materials.

Index Terms ¾ *high school technology literacy, technology education, learning standards, multimedia*

INTRODUCTION

This paper describes an educational project for the development of Web-Tech modules designed to support technology education for grade 9 to 12 students. The project represents a unique team effort between professors from two campuses of the State University of New York (Buffalo and Stony Brook) and technology teachers from six school districts in Western New York and Long Island. Design teams composed of multimedia web-page designers, instructional materials designers, teachers, students, and professors build each module around a selected number of case projects. By exposing students to real-world problems, students become technologically literate and can productively participate in a society that depends heavily on technology. This paper will report the progress made in the pedagogical framework for the modules.

The Backward Design Process

The background design process suggested by Wiggins and McTigue [1] is adopted for the design of Web-Tech modules. The process, as illustrated in Figure 1, consists of three stages.

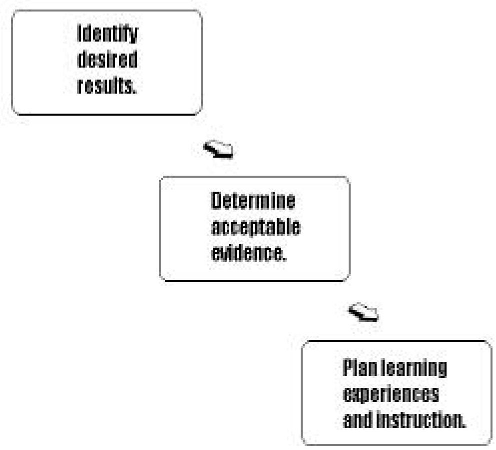

FIGURE 1
STAGES IN THE BACKWARD DESIGN PROCESS

Stage 1 – Identify Desired Results. We examine in this stage the ITEA's Standard for Technological Literacy (SFTL) [2] and the National Research Council's National Science Education Standards (NSES) [3]. Since there are all together twenty standards in SFTL and additional related technology standards in NSES, it is necessary to select and prioritize learning outcome requirements. A three nested-rings for learning prioritization, shown in Figure 2, is useful to demonstrate the classification of learning importance in each case project in modules. The highest priority, the enduring learning basically covers big pictures, the central learning outcome. It is the critical concept or principle that we would

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This research was supported in part by the Elementary, Secondary, and Informal Education Program for Education and Human Resources of the National Science Foundation. Useful discussions and guidance from Gerhard Salinger and Theodore Lewis are gratefully acknowledged.

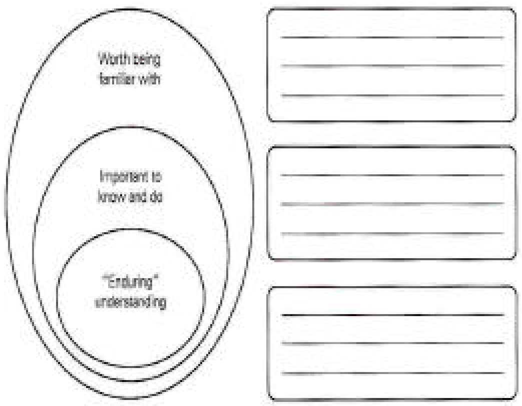

FIGURE 2
ESTABLISHING CURRICULAR PRIORITIES

like students to retain even if they can't remember the details. Three criteria are used in selecting enduring learning outcomes:

- Core concepts or principles at the heart of the discipline. For example, conservation principle of energy is a core concept for enduring learning, while the aerodynamic resistance of transportation systems is not.
- Abstract, counter intuitive and often misunderstood ideas of key concepts and principles for enduring learning are often difficult for students to comprehend.
- Potential for engaging students. By exploring the subject through contextual, cooperative, concurrent, and constructive learning [4], we increase the likelihood of student engagement and sustained inquiry. For example, the question, what can we do to improve the automobile fuel efficiency from its current 30% value? Not only serve as an essential question for exploring energy conservation (waste energy versus usable energy, second law of thermodynamics), but also ties the subject to environmental pollution, social cost/benefit trade-off in technological development. The middle ring in Figure 2 concerns the relevant skill and knowledge builders. These are facts, procedures, techniques and strategies that are useful in the completion of the case projects. For example, the skill of design and construction of electrical circuits is powerful in the learning of energy and power because electrical devices are often used for controlling of energy usage and for energy applications in lighting, heating, communication and entertainment.

The largest ring represents knowledge that students should find it worthwhile to learn. For example, in energy and power modules, it makes sense for students to be conversant about the formation of fossil fuels and why they are not renewable. Such broad-brush knowledge, assessed through traditional quiz questions, would be useful if it is properly posted on the web.

Stage 2. Determine acceptable evidence. The backward process demands that web-tech module design team must include learning assessors. Thus, learning evaluate protocol must be considered up front as a part of module development. A range of assessment methods are used to collect evidence of learning, including those listed in Figure 3 which is taken from reference [2].

Quiz and Test Items

These are simple, content-focused questions. They

- Assess for factual information, concepts, and discrete skill.
- Use selected-response or short-answer formats.
- Are convergent – typically they have a single, best answer.
- May be easily scored using an answer key (or machine scoring).
- Are typically secure (not known in advance).

Academic Prompts

These are open-ended questions or problems that require the student to think critically, not just recall knowledge, and then to prepare a response, product, or performance. They

- Require constructed responses under school or exam conditions.
- Are open. There is not a single, best answer or a best strategy for answering or solving them.
- Often are ill-structured, requiring the development of a strategy.
- Involve analysis, synthesis, or evaluation.
- Typically require an explanation or defense of the answer given or methods used.
- Require judgement-based scoring based on criteria and performance standards.
- May or may not be secure.

Performance Tasks and Projects

As complex challenges that mirror the issues and problems faced by adults, they are authentic. Ranging in length from short-term tasks to long-term, multistaged projects, they require a production of performance. They differ from prompts because they

- Feature a setting that is real or simulated: one that involves the kind of constraints, background noise, incentives, and opportunities an adult would find in a similar situation.
- Typically require the student to address an identified audience.
- Are based on a specific purpose that relates to the audience.
- Allow the student greater opportunity to personalize the task.
- Are not secure. Task, criteria, and standards are know in advance and guide the student's work.

FIGURE 3
TYPES OF ASSESSMENT

Stage 3. Plan Learning Experience. Several key questions must be considered at this stage of backward design:

- What enabling knowledge (facts, concepts, and principles) and skills (procedures) will students need to perform effectively and achieve desired results?
- What activities will equip students with the needed knowledge and skills.
- What will need to be taught and coached, and how should it best be taught, in light of performance goals?
- What materials and resources are best suited to accomplish these goals.
- Is the overall design coherent and effective?

In the Web-Tech Modules, the activities of each case are determined based on the identified desired results in Stage 1 and the acceptable evidence of learning in Stage 2. The design of student learning experience is guided by the six facets of understanding of Wiggins and McTighe[2].

Facet 1: Explanation - Students have opportunities to build, test, and verify theories or explanations. The textbook and teacher theories become uncovered as we tease out and test the assumptions, questions, arguments, and evidence that lie beneath them. Problem-based learning is a vehicle for this process.

Facet 2: Interpretation - Students have opportunities to build their own interpretations, translations, and narratives from primary source texts, events, and experiences. The work will need to make clear that interpretation is always problematic, and that multiple interpretations can and do exist. Oral histories, literary analysis, the case method, and Socratic seminars are useful.

Facet 3: Application - Students have opportunities to apply what they have learned in the classroom to real or realistic situations. Such activities provide students with experience in planning and troubleshooting.

Application to a Case in Energy and Power Module

As an example of the backward design process, we use a case in the Energy and Power module to illustrate the design process. The case is introduced for students to build a safety light system that could be used by a person running, cycling, or roller blading. Figure 4. shows the learning priorities for the case. The enduring learning concerns primarily the abstract concepts called the law of energy conservation and the second law of thermodynamics. The big-picture idea is that one cannot invert a "perfect" energy system with 100% efficiency. Fossil-fuel power plants and automobiles have efficiencies ranging from 40% to 30%. This means that 60% to 70% of the energy from the coal or gasoline is lost in the form of heat to the environment.

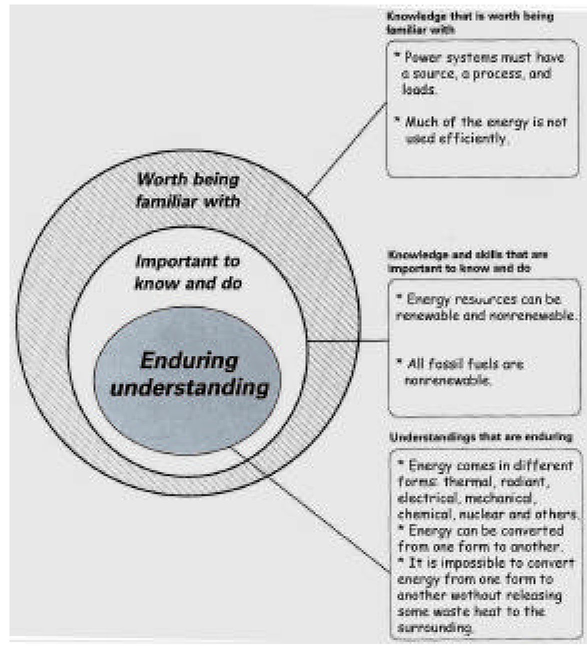

FIGURE 4
LEARNING PRIORITIES

To ensure that the web-based modules offer maximum student engagement, the case is presented in a physical setting in which learning is taking place. Figure 5 shows a study room with a calculator, a notepad; electronic newspapers; a video-TV monitor; bookshelves for encyclopedia and books, case files, and knowledge and skill builders; and an interactive experiment station. Obviously, if learning is to be encouraged, it is important to consider ergonomic and human factors in the design of the study room to make the learning experience pleasant and motivating. A cartoon figure called Andy is created, shown in the lower right corner, to guide students through the learning experience.

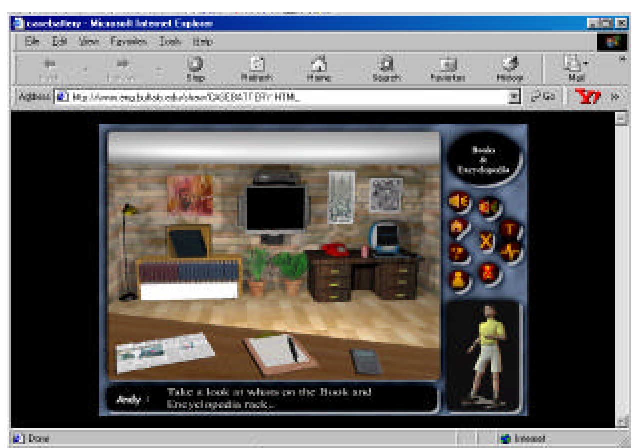

FIGURE 5
STUDY ROOM

Multimedia Resources Production

The multimedia resources used in the Web-Tech modules consist mainly of video segments, text, interactive softwares, graphics, sound and music.

Video segments are produced to introduce enduring learning and design challenge (Figure 6). In this case, the design challenge is defined as the design and construction of a safety light system that uses a portable alternative energy source. Students will conduct energy balance analyses and compare the energy conversion efficiencies of alternative energy systems. Students will use results from their energy balance analyses to draw conclusions on effects of energy usage on our environment.

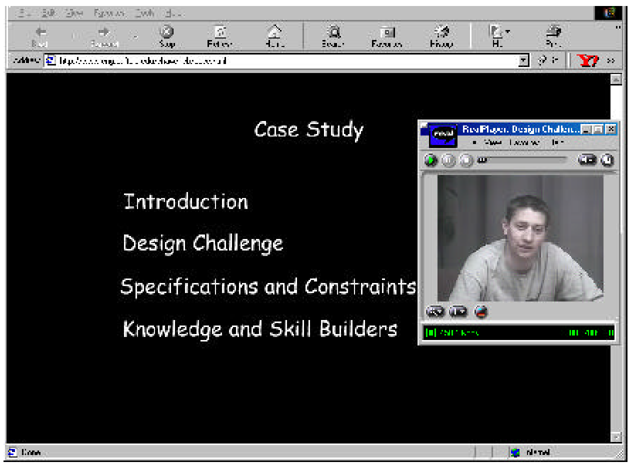

FIGURE 6
DESIGN CHALLENGE

Considerable amount of text displaced on screen is used in modules (Figure 7). Technical and specialized terms, such as design, specifications and constraints, brainstorm, are linked to the encyclopedia and books for just-in-time learning. Students can highlite any part of text and copy it to the notepad.

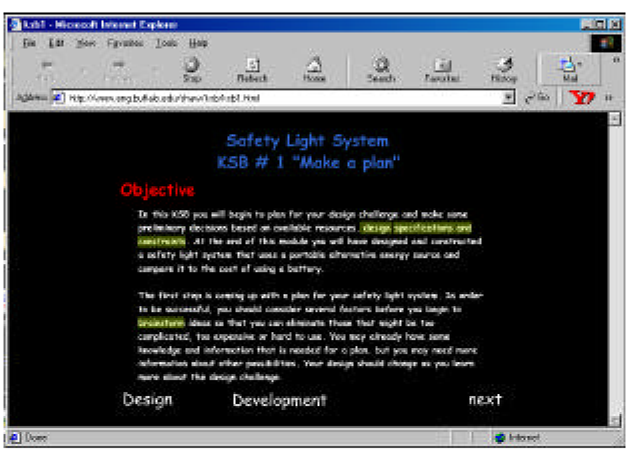

FIGURE 7
KNOWLEDGE AND SKILL BUILDERS

Newspaper clips are provided by directly connecting to such electronic news websites as the New York Times, CNN, and other major news organizations. For example, recent developments in energy policy and California energy crisis are offered for the safety light system case to facilitate contextual learning.

Extensive graphics are used to explain technical terms and devices. Figure 8 shows a graphical representation of the basic structure of a silicon photovoltaic cell in the encyclopedia.

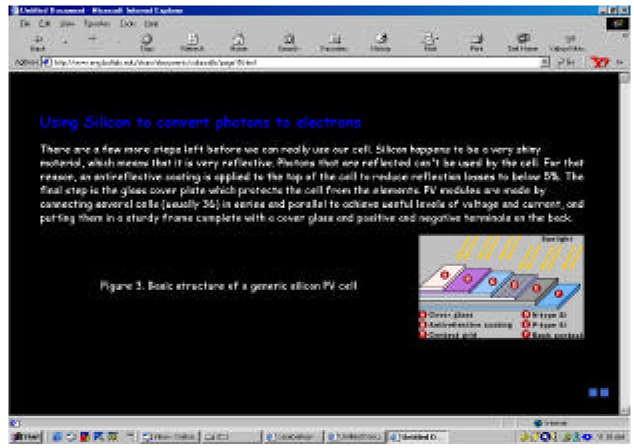

FIGURE 8
BOOKS AND ENCYLOPEDIA

Several sources of sound were used in the module: non-copyright pieces of music are introduced as background music. Sound cues are used to guide students through the modules. Scripts produced for the modules call for a female and a male narrator.

Each case contains four to five knowledge and skill builders (KSBs) which cover all aspects of learning priorities. Specialized softwares, such as the Electronic Workbench for electronic circuit design, are used in KSBs to engage students in specialized technical areas. Figure 9 shows the design of a safety light system using the Electronic Workbench.

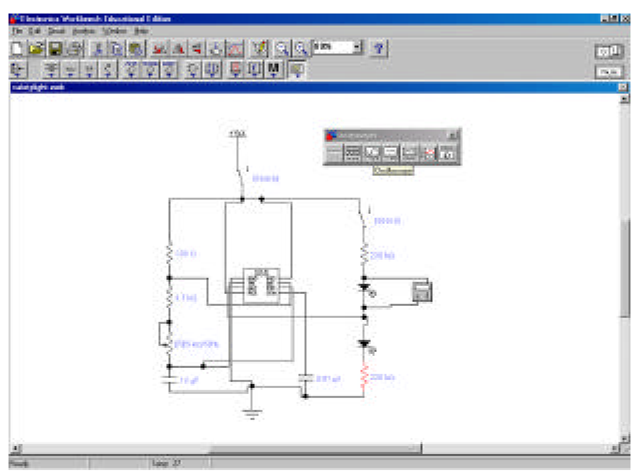

FIGURE 9
ELECTRONIC WORKBENCH

CONCLUDING REMARKS

This paper reports the progress of a project for the development of web-based instructional materials based on the Standards for Technological Literacy. The modules are designed using the backward design process to ensure the compliance of Standards and quality of learning. Each case is constructed to offer students opportunities to build, test and verify theories and explanations. Real-world problems provide students with experience in planning and optimization, and group communication.

Although there is nearly universal agreement on the usefulness of technology literacy in high schools, the lack of suitable instructional materials and associated problems in staff development have impeded the progress of technology education. There are several major difficulties in the development of technology educational materials: (1) The technology field is so diverse and complex that it is difficult to teach the subject to high school students in a meaningful way, and (2) unless basic concepts taught in the classroom can be connected to the real world through hands-on projects and applications, students have often been uninterested in the study of science and technology. Our project seeks to address these issues to facilitate technological fluency at the high school level. The case-based approach employed in the modules has been well tested in other diverse and complex fields (e.g. business, law, and medicine). We believe that the web-tech modules will help to impart excitement to technological learning in the nation's high schools, and should ultimately be readily expandable to middle and primary schools as well.

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