Technology Literacy Enhancement for Precollege Students

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Abstract: Although there is nearly universal agreement on the usefulness of technological literacy in K-12 education, 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 K-12 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. The present project seeks to address these issues to facilitate technological fluency at the high school level. The case-based approach employed in the TMs has been well tested in other diverse and complex fields (e.g. business, law, and medicine). We believe that the TMs will help to impart excitement to technological learning in the nations high schools, and should ultimately be readily expandable to middle and primary schools [1].

Keywords: technology education, case study, web-based, literacy enhancement, K-12

1. Introduction

This paper describes an educational project for the development of technology modules(TM) designed to support precollege technology education. The project is driven by the key ideas and learning abilities identified in the recently published Standards for Technology Literacy (SfTL) by the International Technology Education Association (ITEA)[2]. The contents of the TMs also relate directly to the technology standards and benchmarks of Project 2061:Science for All Americans of the American Association for the Advancement of Science [3]. This project is a collaboration of engineering and technology Education faculty members from two SUNY campuses working with high school technology teachers to design and develop six TMs that are accessible via the World Wide Web [4].

2. Rationale

It has been well documented that the present educational system in the United States is not producing the number or quality of technically educated workers that our society will require over the next decade [5]. Despite the remarkable technological advances, which have emerged as we move into the next millennium, technology education is still an emerging discipline in our high schools. Although the requirements are different for various states, many students in grades 9 to12 have the option of completing high school courses or sequences in technology education. For example, students in New York State are required to take three or five unit elective sequences to fulfill their graduation requirements. Furthermore, in New York, students are now able to substitute rigorous technology courses for the third required unit of study in mathematics or science for a New York State Regents diploma.

Perhaps one of the most pressing problems confronting present technology curricula is the weak background of the students in technology education programs; such students have generally avoided rigorous science and mathematics courses [6]. The target audience for the TMs includes not only those high school students who may pursue further study in science and engineering, but also those who may not major in science in college or may never attend college. All of these students will require a good working knowledge of mathematics, science, and technology when they enter the work force [7].

Generating excitement in technology education is the key to creating more technologically informed high school students. To do so, the project relies on the use of computer-assisted simulation. The high-performance computation and display capabilities offered by relatively low-cost personal computers have dramatically changed the field of computer simulation. It is now possible to learn the essence of such technological subjects as structure mechanics, fluid dynamics, heat engines, digital electronic circuits, signal processing, and circuitry engineering design principles by using computer graphics with input-output-feedback relationships. This approach leaves the complex formulations that deter so many beginning students, for more advanced learning at a later stage.

A problem limiting technology education is that advances in the field often are too rapid for educators to keep abreast of recent progress. Much of present practice in the United States (and in the UK and other Commonwealth countries) derives from programs that are rooted in the craft tradition (Industrial Arts in the US, Crafts teaching in England), where the focus is primarily on ergonomics and aesthetics [8,9]. We believe that technology education not only can retain this focus, but can also integrate learning in science, mathematics, and language. The project materials will enable educators to consider the interplay between engineering design, mathematical analysis, and scientific inquiry. Supplemental materials, such as those developed herein, will allow teachers to communicate the excitement of cutting-edge technological fields and shift the practice of technology education from a discipline characterized by an industrial design perspective to one characterized by an engineering perspective [10].

The TMs are designed not as a textbook, but are supplementary materials prepared to enable teachers to draw upon their own experience and to enhance and support their technology education curricula. Most schools now adopt a printed text in the general area of principles of engineering or use a collection of notes prepared by teachers in engineering design, manufacturing, and electronics. The web-based modules are arranged in sections that may be downloaded to adapt to a teacher's specific curriculum. The web-based materials are also available in CD-ROM form for those schools without access to the World Wide Web.

3. Learning Goals

The TMs are designed to support high school technology education. Teachers can package materials from the modules appropriate for the specific experiences and teaching objectives of their technology classes. The contents of the TMs are parallel to the five overarching themes around which Standards are written: Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World [2,11]. The goals for the project are directly related to these themes. They include common technological concepts and principles (modeling, optimization, systems thinking), relationships among technology, people and the environment, and utilizing technological products and systems.

The principal learning objectives are as follows:

1.Name, describe and apply basic concepts and principles of technology as well as the processes and critical thinking used to resolve technological problems.

2.Give examples of the complexity of interrelationships between technology, individuals, and society and the environment.

3.Describe situations in which the solutions to technological/societal problems involve trade-offs and compromises.

4. Name, describe and demonstrate some of the skills required to participate in a technological world. These include communication skills, skills in using technical tools and resources, and skills in applying mathematics and science.

The program hopes to move beyond enhancing academic and career opportunities to teach students to be technology-literate citizens who can make technology-informed social, political, and personal decisions, and understand that technology is the result of combining human ingenuity and resources to meeting the needs of society. After completing these modules, students will be able to:

1.Demonstrate an understanding of engineering systems by combining scientific principles and practical constraints.

2. Participate in the interactive design of engineering systems.

3. Name and give examples describing aspects of the environmental and societal impact of technology.

4. Apply the operation of engineering systems based on input and output considerations and human factors in system control and reliability.

5. Model engineering systems using narrative, graphics, and mathematical expressions.

6. Give examples of engineering ethics in terms of legal and social responsibilities of engineering decisions.

7. Demonstrate the use of mathematics/science/social science/language skills through applications.

Technology studies are an excellent medium for developing students' life-long learning skills. One of the program's pedagogical approaches is designed to emphasize case-based projects, which foster cooperative learning, consensus building, and teamwork. By exposing students to real-world problems, which exhibit the tension between theory and practice, such case studies will also help students develop critical analysis and problem-solving skills. Communication, interpersonal relationship, and motivational skills also will be integrated into the technology modules.

4. The Learning Strategy

The development of module materials is based on the following criteria [12]:

Learning only becomes meaningful and interesting if students perceive connections between what they know and what they are trying to learn. Thus, **contextual** or situated learning should be the paradigm for instructional design. Students need to learn concepts, strategies, and habits of the mind that help them see how the various aspects of an increasingly technological world are connected.

We need **interdisciplinary** curriculum modules that engage students in relevant problems and the study of technological systems. These materials besides providing contextual learning and study of unifying concepts that connect seemingly unrelated events, must also provide many opportunities for **cooperative learning**. We develop learning environments (curriculum and instruction) that require skills for carrying out the adult roles that high school students will soon have to assume, such as participation as an effective team member is one such skill.

We should also design learning environments that model some of the highly successful techniques currently used by business and industry. For example, the just-in-time manufacturing approach can be applied to education in what can be called **just-in-time learning**. In this approach to learning, concepts and skills are learned as needed to solve problems or design systems. A second example is the use of concurrent engineering in programs that are designed to achieve outcome-based education. In other words, the various aspects of a contextual learning system must be integrated so that we may design optimum learning environments. For example, in studying the evolution of conventional TV systems to a HDT (High Definition Television) system, students need to integrate the study of human factors, governmental regulatory agencies, the science of pulse code modulation and the mathematics of digital systems as well ideas of consumer acceptance and international competitiveness.

The curriculum and learning activities that transpire within the classroom must be designed to foster student **construction of their understanding** of the world in which they live. Any meaningful discussion of educational reform, therefore, must focus explicitly and directly upon the design and development of curriculum materials and instructional strategies that encourage student understanding and application of important concepts.

5.Case-Based Projects

The learning packages that teachers can adopt to suit their specific learning philosophy and environment are organized around case-based projects [13]. Typically, seven to ten cases are developed for each module. Each case represents a real-world technology situation that students can readily identify in their daily lives (contextual learning). One example would be the design of an energy efficient house through retrofitting of better lighting systems. The various aspects of energy-efficient homes (e.g. better insulated envelope, programmable thermostat control, use of alternative renewable energy sources, etc.) are considered in a systemic manner as new energy technologies are introduced for the design of a comfortable and productive environment that consumes a minimum amount of nonrenewable energy sources.

Each of the case-based projects is based on themes that relate to technology-based systems and design problems. Teachers are provided with specific guidelines for engaging students in design, modeling and optimization activities and projects. Each case includes the following components: 1.Overview- provides an abstract of the design and other problems that relate to the theme of the case. 2. Definition of design and related problems - systems analysis, modeling and optimization learning activities are also described. 3. Performance objectives- specification of learning outcomes that the case projects and learning activities are designed to help students achieve. 4.Concept Matrix: Identifies how the case-based learning activities relate to the six major conceptual themes of the principles of engineering program namely, design process, systems analysis, modeling and optimization techniques, technology and society interactions and engineering ethics.

6. Concluding Remarks

One of the common pitfalls in high-school technology education is content-oriented teaching in which teachers, acting in their traditional role as lecturers, try to cover a broad range of subjects in a very short period of time (The mile-wide-and-inch-deep syndrome). The case method emphasizes process-oriented learning and provides students with an environment in which they may become experts in the assigned subjects in order to contribute to the design of a complete technological system [14].

Case discussions provide students with the opportunity to learn by listening to the views of other teams and to express their views as a team. Guided by probing questions from the teacher, students develop critical thinking, problem solving, and interpersonal communication and persuasion skills. Although students may be frustrated by the lack of one perfect answer to any case question, the case approach closely reflects the real-life situation in nearly very profession.

7. References

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8. Acknowledgments

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