AC 2001-459: High Technology Focused Curriculum Materials For High School Science Instruction

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Abstract

Today's high school students, while familiar with high technology as users, frequently fail to connect underlying scientific principles to the technologies that enable their lives in so many ways. We report on initial efforts aimed at providing high school science teachers with technology-based materials, or modules, that they may employ to enhance the presentation of science topics within the guidelines of a state approved curriculum. These materials support the teacher in the normal mode of teacher-centered instruction, considered by both teachers and students to be important [1]. Since topics must be presented within time constraints, modules must replace current classroom materials with content that covers the mandated science theory and practice and in addition, presents the technology connection all within the time frame allocated by the instructors' current lecture format.

Specific topic modules are structured to include three parts: the Basic Lesson Topic, Teacher Materials, and Assessment Tools. An example module title is "Problem Solving" with a Basic Lesson Topic focused on "Precision and Accuracy." A team that includes faculty from university, community college, and regional high schools develops each module. Although module use varies with course and instructor, one protocol is common. After preparation and planning, the teacher employs a stand-alone module provided video presentation that includes both live-action and animation depicting the science and a technology connection. Support and follow-up class sessions employ traditional lecture materials in the form of transparencies, black board notes, classroom practice and homework problems, classroom discussions, and laboratory exercises, when appropriate, that are also provided as module materials.

This paper presents the architecture, and content of an example module prepared for delivery to physical science, chemistry, and physics classes that include grades 9 through 12 during the present school year. One goal is to assess the impact of a module on students' topical interest level, their knowledge retention, and finally whether their exposure to a technology's connections with the underlying science increases the students' awareness of or interest in the pursuit of technological careers. We discuss our approach to planning and implementation of this assessment process.

Introduction

High school students frequently fail to connect the basic scientific principles learned in their course work with the technological marvels that many of them make use of daily. The principles behind such items as portable phones and pagers, personal data assistants, along with more familiar high tech tools such as computers, pocket calculators, and TV/VCR's with remote control are a complete mystery. Our goal, associated with an NSF Advanced Technology Education (ATE) grant aimed at developing a workforce for the semiconductor or high technology manufacturing industries in Florida, is to increase high school students' high technology awareness. The objective is to engender an interest in pursuing technology, engineering, or science related careers by providing students with connections between technology and its underlying science as part of their normal state mandated science instruction.

The key component in this effort is the teacher who is responsible for the delivery of the curriculum. Interactions with regional high school faculty over the past year and one half have resulted in three clear messages. First, a set of disjoint high technology materials and examples that the teachers must integrate into their courses would simply not be used. Second any materials provided must match the time constraints associated with typical lecture formats. Finally, any new material added to the curriculum must be consistent with the guidelines of a state approved curriculum. Cognizant of these constraints our team of educators set about the development of technology based modules that could be used by high school faculty to enhance the presentation of their science topics.

This paper reports on our initial efforts to develop and provide these module materials. The user interface, the basic module architecture, and samples of module content are presented. Finally a discussion of our anticipated assessment process is presented.

Module Structure

The early stages of module development are focused on the selection of topics and delivery approaches. High probability of use by high school teachers was the driving selection factor. To accomplish this task, the high school academic community was approached in a somewhat novel manner. Rather than go to the teachers with surveys and questions, our group offered workshops that allowed interaction with high school faculty as part of their professional in-service days for science teachers from across the county. As background information, Hillsborough County has the 12th largest school district in the country with 16 high schools, 150,000 students, and 8,000 teachers. (http://www.sdhc.k12.fl.us) In this nominal half-day professional experience local science teachers were provided with an introduction to vacuum technology with simple hands-on experiments and demonstrations that could be implemented in their home schools with minimal materials. Technology related content on applications of vacuum in integrated circuit manufacturing, fluid processing of materials, and environmental engineering were also provided. Feedback from the teachers attending these workshops allowed our team to focus on those components of the workshop that were useful to teachers and to identify content that required more development.

Two other important outcomes occurred during these workshops. Our group was introduced to a sample of teachers from across the region in a positive, collaborative manner. Second, the recruitment of advisory participants, faculty mentors, to help design effective module content and delivery approaches became very easy.

In regular meetings with our growing group of university and high school educators, frank and open discussion provided insight into what practitioners would find useful in their course delivery. The principle findings were that high school faculty has a prescribed and rigid set of outcomes that must be adhered to that are associated with the state mandated curriculum. Further, the timing of the delivery of topic materials is pre-established. Therefore, to have any probability of use by teachers, technology content loaded materials must conform to these pre-established time and sequence constraints as well as provide mandated topically relevant content. In other words, developed modules must replace current classroom materials with content that not only covers the same mandated science theory and practice, but in addition present a technology connection all within the time frame allocated by the instructors current lecture format.

It should be noted that care was taken to determine and assess those topic areas that would provide both use and utility to faculty. In particular, effort was spent to identify and discuss areas and topics that would not be explored because they were generally difficult for the teacher to deal with. As suggested, this difficulty was primarily due to allotted time limitations. However, in some cases, topics were identified that, in the teachers' opinion, had skill requirements that didn't match the students' current academic level.

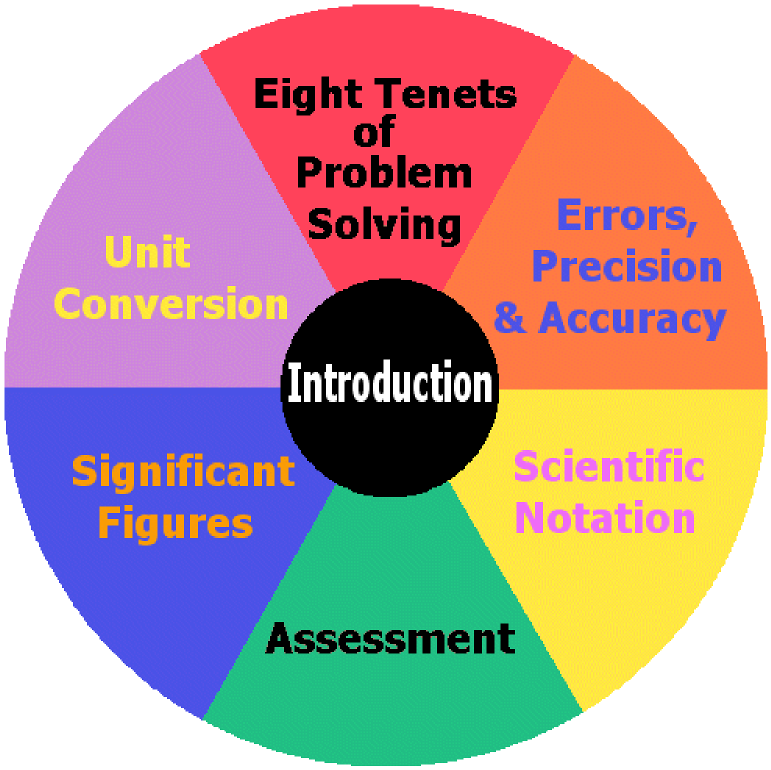
Out of this effort came the first two modules. The first produced and introduced over this academic year is focused on problem solving. Because "Problem Solving" is a crosscutting skill required of all scientific pursuits it was chosen as our first module topic. The second on light and wave properties is still in development and will be completed after the "Problem Solving module has been completely tested and assessed.

Implementation

A multimedia approach was chosen to transfer the module content to teachers. The consensus among our teachers was that all schools had video delivery capability and that computers with CD-ROM drives were available to faculty. A videotape lecture supplement was developed and provided using live and computer-animated content introducing the problem solving topical area. The CD-ROM was developed containing all of the supporting materials for the module. The user interface screen that loads when the CD is inserted is shown in Figure 1. The sections of the wheel including the hub, introduction area, are html "hot" such that clicking with the mouse in any of these areas takes the user to the content supporting that sub-topic.

The architecture of the interface and module content is shown in Figure 2. Included in the module is an instructor orientation giving module background information and a video describing typical instructor usage. Within the wheel structure of Figure 1 for "problem solving" are five sub-topic content areas and an assessment area. Each sub-topic area has power point presentations and slides for printing overhead transparencies, portable document format (PDF) files including handouts, student exercises, quizzes, and keys to exercises and quizzes. The assessment tools provided to the teacher include an attitude scale for assessing the students' technology and science awareness. Further, there is a checklist for the teacher to complete

Figure 1. Problem Solving-User Interface with HTML "hot" zones for module content navigation.



that describes the module components that they used and requests their feedback and evaluation of the module along with their comments and observations regarding possible product improvement. Finally a sample module student quiz is provided.

Assessment

To date the Problem Solving module has been tested on a limited basis in four high schools and four classrooms. As a minimum, during each presentation/use, a group member passively made in-class observations and noted the students' response to the material. The objective is to quantify the students' response to the material by observing the level of and any changes to their behavior while the module was being presented. On occasion video was acquired of the classroom while the module was presented.

These two assessment tools although invasive were useful in the initial phase of implementation of the modules. However, at this point, it is not possible to assess whether the module supplements or facilitates learning until teachers use the entire package and administer the complete set of assessment tools provided. In addition, the overall goal of the project is to

Figure 2. Problem Solving module architecture.

Problem Solving Module

Instructor Orientation
- Module Background, Instructor Use Video

Module Page
- Video, Credits,
- Module Wheel
  - **Summary**
    - Introduction, Site Map
  - **Eight Tenets of Problem Solving**
    - Presentations, Student Handouts, Student Exercises, Exercise Keys, Quizzes, Quiz Keys
  - **Errors, Precision & Accuracy**
    - Student Handouts, Student Exercises, Exercise Keys, Quizzes, Quiz Keys
  - **Scientific Notation**
    - Presentations, Student Handouts, Student Exercises, Exercise Keys, Quizzes, Quiz Keys
  - **Significant Figures**
    - Presentations, Student Handouts, Student Exercises, Exercise Keys, Quizzes, Quiz Keys
  - **Unit Conversion**
    - Presentations, Student Handouts, Student Exercises, Exercise Keys, Quizzes, Quiz Keys
  - **Assessment**
    - Assessment Tools, Module Quiz, Module Quiz Key

determine if the modules provide teachers with the opportunity to overlap high technology themes into the science curriculum as students progress through its courses. This spiral overlap of science with technology as it is repeated and reinforced in each science class will ultimately be assessed by student awareness of technology as quantified by the science and technology survey administered to the students.

Conclusion

We have described the development of instruction modules that may be used by high school science faculty that are not only a direct replacement for the basic science content that the teachers are responsible for presenting but in addition include content that is focused on high technology connections back to the basic science. The materials are provided in a multimedia format such that the instructor may easily implement them. In the future we will use the already created technology assessment tools to gather data on the effectiveness of the modules. In particular our goal is to increase the population of students who are able to connect technology ideas with their basic science foundation and in so doing become interested in scientific and technology careers.

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