Teaching Problem Solving to High School and Community College Students: A New Approach

Andrew M. Hoff[1], Marilyn Barger[2], Richard Gilbert[1], Kimberly S. Rogers[1], Joseph D. Hickey[1], Eric Roe[1], and Beth McCullough[2]
(1) University of South Florida, Tampa, Florida 33620 / (2) Hillsborough Community College, Brandon, Florida 33619

Abstract

We present the results of a new approach to adapt and incorporate high technology materials into our state mandated secondary education curricula. This is accomplished by providing secondary and community college teachers with multimedia-based modular materials that may be used to effectively teach problem solving skills to students in 9th grade through community college education levels. This integrated approach uses modular materials jointly developed with secondary and community college faculty to provide a framework that may be used as needed to replace or augment existing course curricula focused on problem solving issues. The available materials in the Problem Solving Module are divided into seven primary sections. Each section provides sample lesson plans and suggestions to teachers on use tactics, lecture material, student worksheets, assessment tools, high technology examples, and video examples using computer-based animations. The materials are at present being tested in high school math, science, chemistry and physics courses as well as in community college chemistry courses. At present the HSTI team is evaluating plans to expand preliminary classroom trials throughout the science programs of the School District of Hillsborough County, 11th largest in the nation.

Introduction

The High School Technology Initiative, HSTI, is a new approach to adapt and incorporate high technology materials into the state mandated secondary educational curricula. Members of the HSTI team believe that instructional modules can be used 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. In addition, the team thinks that augmenting the high school science curriculum with technology content material has a positive impact on students, is attractive to the science and mathematics teacher, and is an effective, efficient and appropriate approach to connecting technology to fundamental science concepts and mathematics principles. Therefore, the goals of a HSTI module are to: 1) Facilitate the teaching of fundamental science and math skills through high technology applications and presentation techniques. and 2) Increase both the teacher's and the students' awareness and appreciation of the interdependence among science, mathematics, technology, and society.

The background premise driving all HSTI modules is to provide quality content materials that emphasize the connections that science and mathematics have with technology in a format that addressees appropriate educational standards while being easy to implement in a variety of classroom environments. Since high school science and mathematics topics are presented within school district imposed time constraints, HSTI modules replace current classroom materials with technology-based content that still covers the mandated science theory and practice. HSTI modules present technology content lessons within the time frame allocated by the instructors' current presentation format. The modules provide teachers multimedia presentation options for each lesson. In addition, a variety of lesson reinforcement and assessment tools are included. Each module contains, presentations, work sheets, in or outside class activities, as well as quizzes and tests. In summary, each HSTI module offers high school science and mathematics teachers curriculum content material that emphasizes technology as it relates to science and mathematics as well as providing a variety of technology based multimedia options as delivery vehicles.

A HSTI module is developed not only with the high school science educator presentation in mind but with the science and mathematics content created exactly as the high school curriculum has dictated. The HSTI development team consists of high school science teachers from schools in Hillsborough and Polk counties, university and community college professors, engineering Ph.D. students, and multimedia professionals. The typical mode of operation for the team is to review with the high school teachers the topics currently presented in the county school district curriculum. Discussions on how topic items comply with county and state content requirements lead to the module's science and mathematics content as well as identification of the science, mathematics and/or technology standard that the module material addresses. At this middle stage in module development, the science and mathematics objectives are blended with technology and engineering related examples. The final result is a module that integrates technology with the specific science principles and mathematics skills required of the lesson plan the module is to support.

Module Development

The HSTI approach is based on the premise that modules are to be used by high school science and mathematics faculty. It is also founded on the belief that high school teachers are not comfortable with nor have the leeway to introduce new materials into their already crowded teaching schedule. Thus, the high school academic community is integrated into the HSTI project in a somewhat novel manner. Rather than go to the teachers with surveys and questions, HSTI offers technology content workshops for the School District of Hillsborough County (SDHC) high school teachers that allow interactions with high school science faculty as part of their professional in-service days. SDHC is the 11th largest school district in the country, with 16 high schools, over 150,000 students, and at least 8,000 teachers.

Feedback from the science and mathematics teacher workshop attendees identified technology components of the workshops that are useful to teachers. It also indicated technology content areas that required more development. In addition to this feedback, four SDHC teachers that represent different aspects of the school science curriculum have been recruited from the workshops to join the HSTI team and work directly with the USF and HCC personnel on new modules.

The Problem Solving Module

The Problem Solving Module, consistent with all HSTI modules, has a common or shared architecture and visual structure. This architecture has evolved from an iteration process that incorporated feedback from the HSTI high school teachers and other SDHC high school curriculum content experts. The architecture of the module interface and content for "The Problem Solving Module" is presented in the module organization chart shown in Figure 1. The module initially presents two visual choices to the teacher. One of these major module choices takes the teacher to content designed to provide the instructor with an overview of the module architecture along with hints for its use. This is the information shown on the left part of the organization chart. The module provides seven hot links that lead to the teacher resources identified on the introduction side of the organizational chart as: *Module Structure, Instructional Components, Lesson Plans, Assessment, Standards, Module Site Map, and Feedback & Contact Information*.

Aside from the background information provided the most important information available to the user from the instructor portion of the module are the lesson plan options. The Lesson Plans component is further subdivided to provide lesson plans for Physical Science, Chemistry and Physics courses. Understanding that a HSTI module will never meet its educational objectives if teachers do not use it, these lesson plans suggest how the teacher can integrate the units into their science curriculum. They were developed in concert with the teachers who "beta" tested the module, and reflect the in-class trials performed during that phase of testing.

The Standards page is also a significant component of the teacher introduction to a HSTI module. This page is accessed via the "Standards" hot link button on the graphical user interface, GUI, and offers a mathematics and/or science standards options. The page provides a checklist of those Florida educational math and science standards, 9-12 Sunshine State Standards, that are addressed by each unit of the module[1]. The complete set of 9-12 Sunshine State Standards may also obtainable from this url page in PDF file format.

The other major module choice available to the teacher takes the teacher to the instructional content portion of the module. This is the information shown on the right part of the module organization chart. Each content topic selection provides lessons and multimedia presentation approaches to select from.

The Visual Instructional Element Window, *VIEW*, is an important component of each HSTI module. A HSTI VIEW provides a window of opportunity for the teacher to present a HSTI content lesson in a multimedia format. VIEW's are packaged as a PowerPoint presentation, a computer based avi or as a video. A number of schools do not have access to multimedia display technology but most have video tape display capability. Therefore, as a standard policy applied to the Problem Solving and to other HSTI modules, video materials are provided in a HSTI module as separate VHS tapes. Videos use live and computer-generated content and strive to connect the student to the science and technology behind the high-tech devices they use in their every day lives, while teaching basic problem solving skills. Computer playable "avi" versions of module videos are also included on the module CD-ROM.

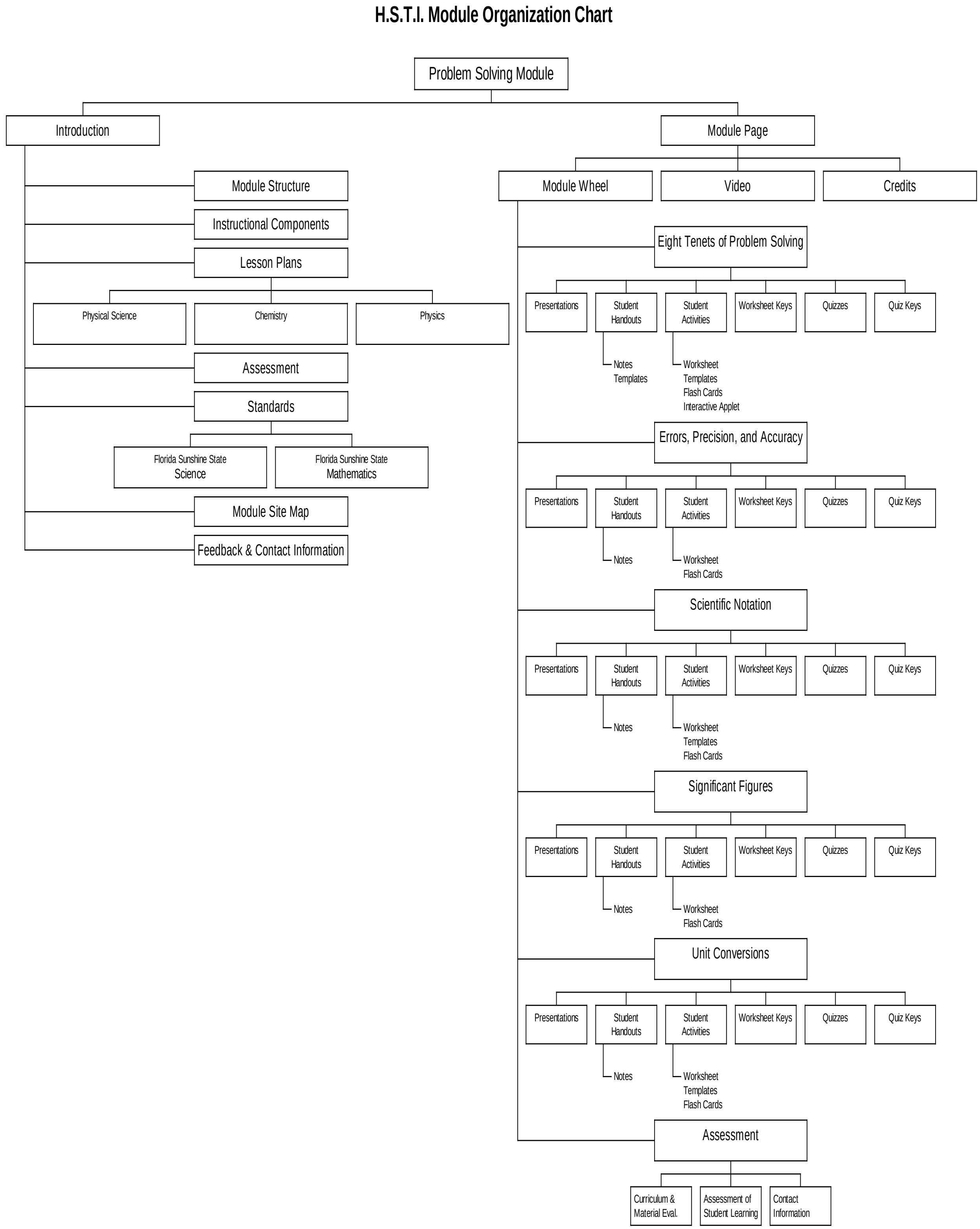

Figure 1. HSTI Module Organization Chart; Problem Solving.

As suggested by the module organization chart in Figure 1, content materials are provided in the format of *Presentations, Student Handouts, Student Activities, Worksheet Keys, Unit Quizzes,* and *Quiz Keys*. The Presentations are in PowerPoint format. These VIEW's are to be shown in whole or in part during a class period. The Student Handouts outline a systematic approach to practicing the concepts presented in this section of the module. The Student Activities include worksheets, templates, and interactive applets. The worksheets provide the students with the opportunity to apply the techniques learned from the handouts and presentations by working example problems, and will gauge the student's understanding of each topic. The templates are workspaces in the structure introduced in the presentations, handouts, and worksheets. They are intended for use with text exercises. HSTI modules also provide an interactive applet as a set of flash cards. Flash cards reflect a time-honored method of knowledge reinforcement. This HSTI version of a deck of flash cards is a computer-based tool for the students to self assess their knowledge of the unit's material. Additional reinforcement and/or self-assessment interactive computer activities are module and/or module unit dependent. Finally, each HSTI module unit contains Worksheet Keys, Unit Quizzes, and Quiz Keys to facilitate student assessment of the module materials.

Assessment & Evaluation

Evaluation and assessment of HSTI modules has a three-tiered structure with the first two of these aspects provided in each module. One evaluation and assessment perspective is if and then how the teachers use a HSTI module as well as their like (dislike) of a module and/or a module unit. The other perspective is if students benefited from module use in the classroom. The third assessment and evaluation aspect is the "in-house" and "alpha" testing performed by the HSTI team as a module moves through production to a final product.

Data Base Construction

All evaluation and assessment tools to be used by HSTI are designed for easy transfer to a database. The databases to be developed will use a relational database model. Within this model, information is divided into several tables and linked together using a primary key. Advantages of using a relational database model include the ability to handle complex relationships within a single database. Thus, even though a number of tables that contain many relationships can be envisioned, the HSTI relational databases will facilitate mining for hidden data.

A number of different types of mining relationship options will be available via the HSTI database. One-to-one relationships can be constructed such that for each record within a table there is a corresponding record within another table. Another possible relationship type is a one-to-many relationship, where there is one record within one table and many corresponding records in another table. For example, since there are many questions associated with a course, this type of relationship is useful when examining interactions between a course and its questions. Finally, a many-to-many relationship can be examined. In this type of relationship there are many records within each table that correspond with each other. The relationship between the questions and answers is an example of a many-to-each other relationship. An example here is when there may be many questions that correspond with many student answers. In summary, by using a relational database model to support the Science and Technology Attitude Survey, the HSTI database will have an efficient means of storing and analyzing multiple information from teachers, courses, module lessons and student survey responses.

Conclusions

We have presented a new approach that effectively uses multimedia modules to teach problem solving in the 9-14 educational environment. The Problem Solving module was developed by a team including high school, university, and community college faculty to allow seamless integration into the time constrained format at this educational level. Correspondence to state mandated guidelines and standards is assured. The Problem Solving module has been tested in a limited set of classrooms to this point. It is the teams intention to address district-wide evaluation in the near future.

Acknowledgements

The authors wish to thank other members of the HSTI team; Ms. Karen Loweke, Mrs. Jackie Voulgaris, and Messrs. Al Greenway, Mike Hepburn, and Brad Smrstick for their continued contributions and support in this effort.

References

[1] Florida Department of Education, Sunshine State Standards, url: http://www.firn.edu/doe .

ANDREW HOFF has worked in microelectronics manufacturing for over twenty years. He received his Ph.D. in Electrical Engineering from The Pennsylvania State University in 1988. Since then he has worked at USF in Tampa, Florida in the Center for Microelectronics Research and is presently an Associate Professor of EE. His research interests include the characterization and control of process related defects and contamination, plasma processing of materials, and process induced charging and associated damage in IC manufacturing.

MARILYN BARGER is an Associate in Research in the College of Engineering at the University of South Florida and a Professor of Advanced Manufacturing Technology at Hillsborough Community College, both in Tampa, Florida. She is actively developing programs and curricula for Advanced Manufacturing Technology as well as multimedia educational materials for a NSF Advanced Educational Technology initiative in Florida.

RICHARD GILBERT is a Professor of Chemical Engineering at the University of South Florida in Tampa, Florida. He is actively developing multimedia educational modules in context of a NSF technology initiative within the state of Florida. In addition, he has helped to develop multimedia technical educational materials for Lucent Technologies Inc..

KIMBERLY S. ROGERS is currently pursuing a Ph.D. in Engineering Science at the University of South Florida. She received a Masters of Science in Chemical Engineering from USF in May of 2000. She is involved in creating educational modules under Dr.'s Richard Gilbert, Marilyn Barger, and Drew Hoff. Her research interests also include the application of engineering principles to biomedical research.

JOSEPH D. HICKEY is a Ph.D. candidate in the Chemical Engineering Department at USF. He holds baccalaureate degrees in both Biology and Physics. Mr. Hickey has also had in-classroom experience teaching science and technology to high school juniors and seniors.

ERIC ROE is a Ph.D. student in Chemical Engineering at USF. He received his MS in Chemical Engineering from USF. Prior to his study at USF, he was employed in Research and Development at Tropicana Products. His research interests are Food Engineering, Fluidized Bed Drying, and the integration of engineering and education.

BETH MCCULLOUGH is a Professor of Chemistry at Hillsborough Community College, in Tampa, Florida. She holds an MS degree in Chemistry from the University of Maryland. She is active in programs that encourage and foster high technology education in Florida. In this capacity she has taught in numerous ChipCamps, a program of the Tech-4 Consortium in the state, for high school science teachers.