Active Collaborative Learning In Engineering and Technology Using Industry-Based Case Studies

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Abstract

The main objectives of The South East Advanced Technological Education Consortium, SEATEC are:

- To train faculty to identify and address the technical needs of area industry.
- To upgrade curriculum to meet these needs.
- To produce industry-based case study models that apply active collaborative learning, improve student oral and written communication skills, and ultimately produce better-prepared graduates that will meet challenges in today's global economy.

The current paper describes the SEATEC curriculum development technique and provides a summary of its very promising outcomes that may revolutionize engineering and technology education and increase students' interests in pursuing these programs. The unique partnership with area industry along with the rigorous training of the participating faculty have produced five industry-based case-study models that are interdisciplinary, multi-media enhanced, open-ended, and use active collaborative learning.

I. Introduction

One of the greatest challenges that most students face during their course of study in higher education is relating classroom topics to real-life situations. In addition, active and collaborative learning are not widely used in technical programs. For these and other reasons, many engineering and technology students often find themselves frustrated and sometimes lose interest in pursuing such degrees. The present paper outlines a creative approach to curriculum development and delivery that is designed to improve engineering and technology education and to bring real-world problems to the classroom. In fact, this is one objective of the three-year NSF-funded grant ($1.8 million) entitled "The South-East Advanced Technological Education Consortium, SEATEC." The consortium is a collaborative effort of five institutions across Tennessee. Each team at the host institution includes multi-disciplinary faculties, industry partners, university partners, and high school tech-prep teachers. The SEATEC goals are:

1. To provide national leadership for the development and implementation of case-based instruction in technology and engineering education.
2. To provide opportunities for continuous and appropriate professional development of participating faculty.
3. To assess the effectiveness of the case study approach in teaching technology-related curriculum.

4. To nationally disseminate information related to SEATEC activities, materials, and results, including outcomes of the use of case studies in field-test setting.

The current paper focuses on the first and third goals. It also describes how active collaborative learning can be readily incorporated in the case-based approach.

Long used in medical, legal, and business education, the case method may offer similar positive results in engineering and technological education. Students in these programs benefit from the exposure to industry-based case studies developed by interdisciplinary faculty teams who have identified real-world problems during industry internships and site visits. In addition to teaching specific technical and problem solving skills, the case method integrates the general educational skills such as oral and written communications, teamwork, and information literacy skills.

One of the main outcomes of SEATEC is the production of five industry-based case models that address various issues in the electrical, civil, computer, industrial control, and manufacturing engineering and technology fields. The five case models have been pedagogically developed, reviewed, and field-tested. Assessment tools have been designed with help from prominent learning scientists from the Learning Technology Center, LTC, at Vanderbilt University. The five models were reviewed independently for pedagogical and technical contents and Transfer Task tools have being developed to assess learning. Early findings indicate very encouraging results.

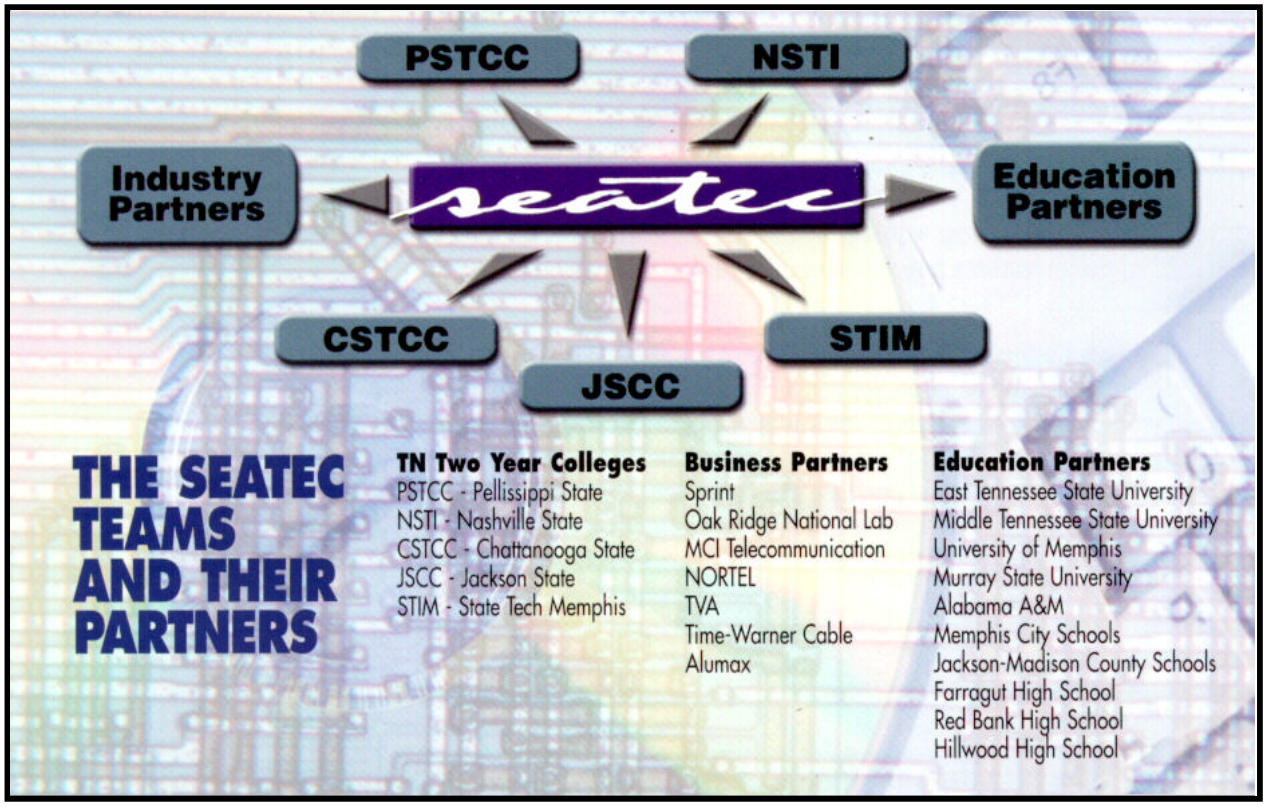
II. SEATEC History

The SEATEC grant is a continuation of an earlier two-year NSF-funded grant entitled "Tennessee Exemplary Faculty for Advanced Technology Education, TEFATE." The purpose of the coalition was to develop a group of faculty who would provide leadership in curriculum development and delivery in emerging technologies. The main outcomes of the TEFATE grant include:

1. The development of twenty-five work-based case studies in the areas of telecommunication, computer networking, and network administration.
2. A comprehensive Internship Guide that helps faculty in other institutions in planning, applying, and using industrial internship experiences effectively in the classroom.
3. A comprehensive Faculty Development Guide that provides a model and the steps necessary for the personal development of any engineering or technology faculty.

These outcomes are available from the SEATEC website at http://www.nsti.tec.tn.us/SEATEC.

The current SEATEC grant builds on the success of the TEFATE approach to curriculum development by expanding the scope of the case study approach to include all engineering and technological fields. The consortium is composed of five technical colleges with representatives from four-year universities, secondary schools, and most importantly from business, industry, and government institutions in Tennessee, Kentucky, and Alabama.



III. Curriculum Development Using the Case-Study Method

Case studies have been proven to be effective teaching tools in various fields ranging from business and finance to medical. Case studies are usually based on real-world problems and allow the students to use their critical thinking and logic reasoning abilities. Collaborative education and team building concept can be used effectively in almost any case-study environment. The use of the sciences, mathematics, technical writing, and oral communication knowledge as well as the SCANS 2000 skills and competencies can be integrated easily in case studies. Most importantly, case studies can make classroom learning an enjoyable experience. The use of case studies in technical education, however, has been somewhat limited. Recently and after recognizing the importance of case studies, engineering and technology educators are trying to follow their counterparts in other fields. As a result, there is a growing need and interests in work-based case studies for engineering and technology education.

IV. System Approach to Problem Solving

We, educators, often notice that most students can solve a specific task or a problem that is well defined and directly related to topics covered in the classroom. On the other hand, most students find much greater difficulties in solving problems that contain additional or unnecessary data or problems that are ill defined or open-ended. However, most problems in the real world are of the latter types. Therefore, fresh graduates face additional challenges during their early years of employments.

In order to better prepare our students, it is proposed that a system approach to problem solving be incorporated in engineering and technology curriculum. This can be accomplished by introducing the student to a real-world multidisciplinary problem that can be broken into smaller tasks or cases. The cases are interrelated by what is called the "Global Challenge." The global challenge and its related cases can be simple for the use at the freshman or high school levels or can be more complex for higher levels.

V. The Case Files Learning Cycle

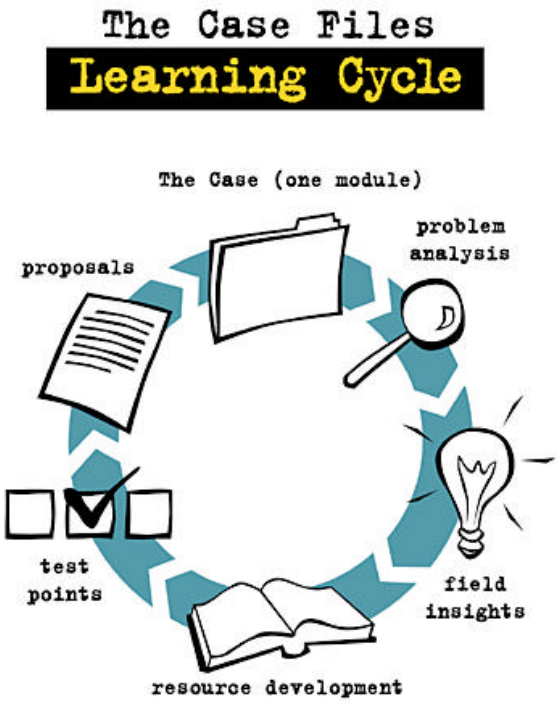
A. Case Structure

One highly effective structure for case studies is the "The Case Files Learning Cycle" shown below. This template is based on a learning cycle that was developed and piloted at Vanderbilt University and subsequently adapted by SEATEC for use in technological education. The model is based on work done by SEATEC, Vanderbilt's VANth Project, and from the framework described in the National Research Council's publication "How People Learn: Brain, Mind, Experience, and School[1]."

Relatively small, problem-based instructional units are designed to complete the learning cycle. These units provide direction, resource, and assessment guidance for faculty and students. The Case Files Learning Cycle is non-linear and can be as robust with information and materials as the faculty determines to be appropriate.

B. Case Components

The case — represents a real-life task, situation, or problem that sets the context for the case.



Problem Analysis — allows students to explore and define the problem. Students often work collaboratively here and engage in active discussions.

Field Insights — a wide range of expert knowledge is available to the students. They can choose video, audio, or text explanations of subject matter presented by leading experts, or they can search for other experts on their own. A link to background information can be also included here.

Resource Development — students are asked to research information needed to solve the case. Initial solution(s) is proposed at this point.

Test Points — students learn to assess their own progress, knowledge, understanding and/or their lack of knowledge. The proposed solution is formalized at this point.

Proposals — at this stage, the finalized solution is presented orally to the whole class and also in a written format. Communication skills are learned, tweaked, and tested in this stage.

Students learning can be asynchronous. That is, at any point in the execution of the case cycle, students can enter and explore any of these categories. As shown at the top of the graph, a case may be considered a “module”. In an ideal learning environment, multiple modules will be developed to support a larger objective. Cases or “challenges” and individual learning objects “modules” are developed using the most effective and or appropriate technology. Video and audio clips, animation, and interactive media as well as regular text files are weaved into each module to meet students’ preferences.

VI. SEATEC Partnership with Industry

The SEATEC faculty used the following methods to identify competencies and skills required by area industry:

1. Industrial Site Visits.
2. Faculty Internships.
3. Conducting DACUM (Develop a Curriculum) Studies.
4. Industrial Partnership.

VI. Multimedia Enhanced Case Studies

SEATEC faculties have found that case-based instruction in technology education is a great way to involve most if not all students in the classroom learning experience. Case studies, especially the multimedia-enhanced ones, offer students the opportunity to learn the needed technical as well as the general education skills in a real-world context. Adding multimedia to written cases enhances the activity level of the students while incorporating the workplace exposure to the student learning experience. Video clips, photographs, and sound clips allow the student to view the work site and interact with the employees even if the industry is located hundreds of miles away. Adding software components to cases allow the student to perform directed research via the Internet, take quizzes on key technical concepts, and receive immediate computer-generated feedback. Students soon find themselves as the facilitators of their own educational experience and can choose how they maneuver throughout the case without following the one "right" path.

VII. Field Testing and Assessment

For the purpose of constructive assessment of the SEATEC approach to curriculum development, the Learning Technology Center (LTC) http://peabody.vanderbilt.edu/ctrs/ltc/ at Vanderbilt University was contracted to assess the effectiveness of the case study approach in technological education. Each of the SEATEC teams identified the courses where field-testing will be conducted. Assessments are currently being performed at colleges and universities across Tennessee, Alabama, and Kentucky. A National Advisory Committee was also formed to monitor the progress in meeting this objective.

Initial field-testing instruments indicated that students often feel as if they are employees at the job site in which the technical problem is taking place. Since case-based instruction is student-centered, students have more responsibility for their own learning, thereby allowing instructors to spend more time facilitating rather than "lecturing". Students graduate with marketable skills and virtual industrial experience. Employers who have participated with SEATEC in the case writing process are enthusiastic about the freshly graduating workforce that is trained in problem-based and case-based learning using an interdisciplinary approach, with critical thinking and problem solving skills, and who possesses the required communication tools.

Another job skill that can be easily implemented through case-based instruction is teamwork. Cases are often assigned as small group work to be completed both in and outside classroom. Groups must share resources and work toward a common goal. This reflects the problem-solving method most often employed in industry: interdepartmental committees. Each of the SEATEC models has components that are easily adaptable for small group work such as communications assignments (reports, memos, and/or oral presentations).

VIII. Encouraging Results

Results from the field-testing of a model case that is written by the author and is entitled "I want My Pizza Hot!" over the past two years have indicated clear and significant improvements in students' performance in the case sections as compared to students' performance in the "control" sections where a "traditional" teaching environment was used. Transfer Task questions were designed to measure students' learning and adaptation to a new situation/problem that is different from those encountered in the case or the classroom. To eliminate the effect of different instructors, the author used the case method in his course entitled "Introduction to Electricity and Electronics" while keeping a "control" section in a multiple-section environment during four semesters for the last two years[2].

IX. Dissemination

Finally, SEATEC members who have published several papers and presented at various international, national, and regional conferences are disseminating the preliminary results of this grant. A web site has been also created to electronically disseminate materials related to the grant. For additional information or to sign up for the SEATEC newsletter and mailing list please check the following: http://www.nsti.tec.tn.us/SEATEC/

X. References

1. Bransford, Brown, and Cocking, *How People Learn: Brain, Mind, Experience, and School*, 1999, ISBN 0-309-06557-7.
2. Sbenaty, S.M., "Assessments and Transfer of Knowledge in Case-Based Instruction — Promising Results!" Proceedings of the ASEE 2002 Annual Conference, Paper no. 3280.

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