Curriculum Development and Delivery Using Industry-Based Case-Study Models

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Abstract

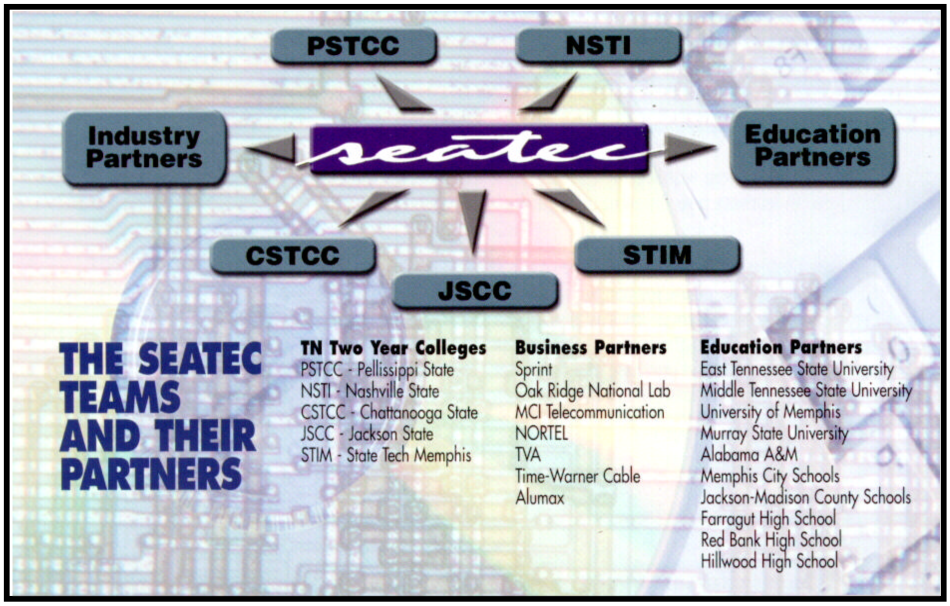
The current paper outlines an innovative approach to curriculum development, delivery, and assessment that may improve engineering and technological education and attract students to pursue these programs. This is one of the objectives of the three-year NSF-funded grant entitled "The South-East Advanced Technological Education Consortium, SEATEC." The consortium is a collaborative effort of five different teams across Tennessee, Alabama, and Kentucky. Each team includes multi-disciplinary faculty members and industry partners. A brief account of the grant's activities will be described and a model case targeted for an introductory course in circuit analysis will be presented.

I. Introduction

In today's fast changing world, companies spend large amounts of money on staff training and development. To reduce costs and training time, employers are increasingly interested in working closely with higher education institutions to transfer the classroom into a real-world learning experience. In addition, employers are interested in improving the way employees apply their acquired knowledge and skills to new settings or situations.

At the same time, 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. Students in the first circuit analysis course, for example, may be engaged in solving series and parallel circuits that are rarely linked to real industry-based problems. What makes matter even worst, at least in some cases, is that active collaborative learning environment is not widely used in engineering and technical programs. For these reasons, many engineering and technology students often find themselves frustrated and sometimes lose interest in pursuing such degrees. In the industrial workplace, moreover, new graduates face additional challenges such as working in multi-disciplinary teams, using oral and written communication skills effectively, and dealing with complex and open-ended problems.

To address these growing concerns, faculties from several institutions across Tennessee, Alabama, and Kentucky are pioneering the development and testing of industry-based case-study approach for the enhancement of engineering and technological education. Five models for the development and applications of case studies that are interdisciplinary, multi-media enhanced, open-ended, and use active collaborative learning have been developed, tested and are being disseminated. This approach brings real-world problems to the classroom and is hoped to enhance learning and retention in these programs. The work is done through a 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 includes multi-disciplinary faculties, industry partners, university partners, and high school tech-prep teachers.



II. Case Studies? In Engineering and Technology Education?

YES! Case studies have been proven to be effective teaching tools in many fields ranging from business and finance to medical. They allow the student to use his/her critical thinking and problem solving and/or logic reasoning abilities. Collaborative education and teamwork can be used effectively in case studies. Integrating the sciences, mathematics, technical writing, and oral communication competencies, as well as the SCANS 2000 skills is made easy through the use of case studies. However, the use of case studies in engineering and technological education has been somewhat limited. Only recently, engineering and technological educators are trying to follow their colleagues in other fields[1-3]. As a result, there are growing needs and interests in industry-based case studies in these fields.

III. Activities to Achieve Objectives

Several activities took place throughout the SEATEC grant, some of which are:

1. Training in Case-Based Instruction: The participating faculty had to go through rigorous training and professional development that included workshops and seminars in case study development and implementation; computer based training, team building, active collaborative education, and leadership training; applying multimedia in the classroom; numerous industry site visits and faculty internship in industry; and in applying and field-testing case studies in technology programs.

2. Professional Development: A "Professional Development Team" was formed and conducted campus-wide in-service sessions at the five participating institutions. In addition, numerous industrial site visits exposed the team members to the latest industrial technological practices and provided the basis for real-world based problems that can be used in case studies.

3. Assessment of the Case-Study Approach: Assessment tools for the case method have being developed in cooperation with the Learning Technology Center at Vanderbilt University http://peabody.vanderbilt.edu/ctrs/ltc/. Cases were reviewed independently for pedagogical and technical contents and transfer tools were developed to measure student learning. Each team identified courses where field-testing is to be conducted and testing results are being analyzed. Surveys of faculty and students were conducted before, during, and after field-testing. Videotaping and outside monitoring were also used. Initial assessments indicate very favorable results.

The first fully assessed case was written by the author and is entitled "I Want My Pizza Hot." It is centered on a non-conventional pizza warmer. The warmer is made of a sheet of conducting material with slits and embedded copper busses. The students throughout the case were involved in making business decisions, calculating the resistance of various conducting shapes, analyzing electrical circuits, discussing basic thermodynamics concepts, and in designing their own proposed products. Additionally, the students were asked at the end of the semester to calculate the resistance of other non-traditional conducting shapes. The results were compared to those with a "control" section of the same course but without exposure to the case method. Early findings indicate very positive and encouraging results.

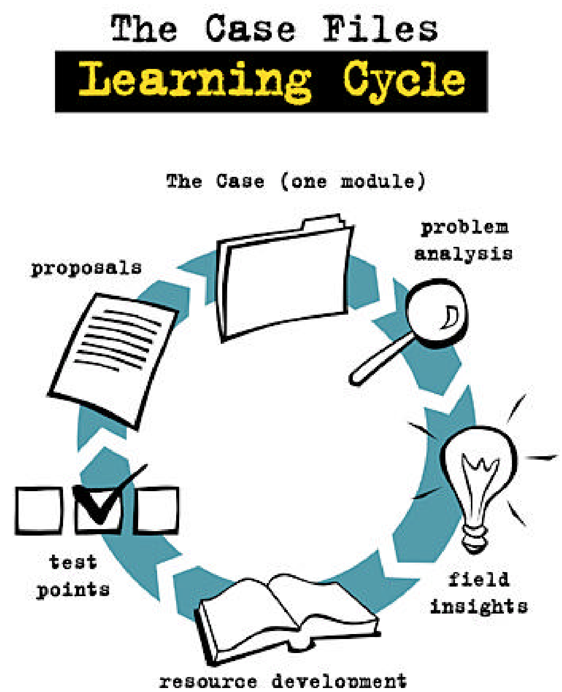
IV. System Approach and Case Structure

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 applications at the freshman or high school levels, or can be more complex for higher levels.

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[4]."

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

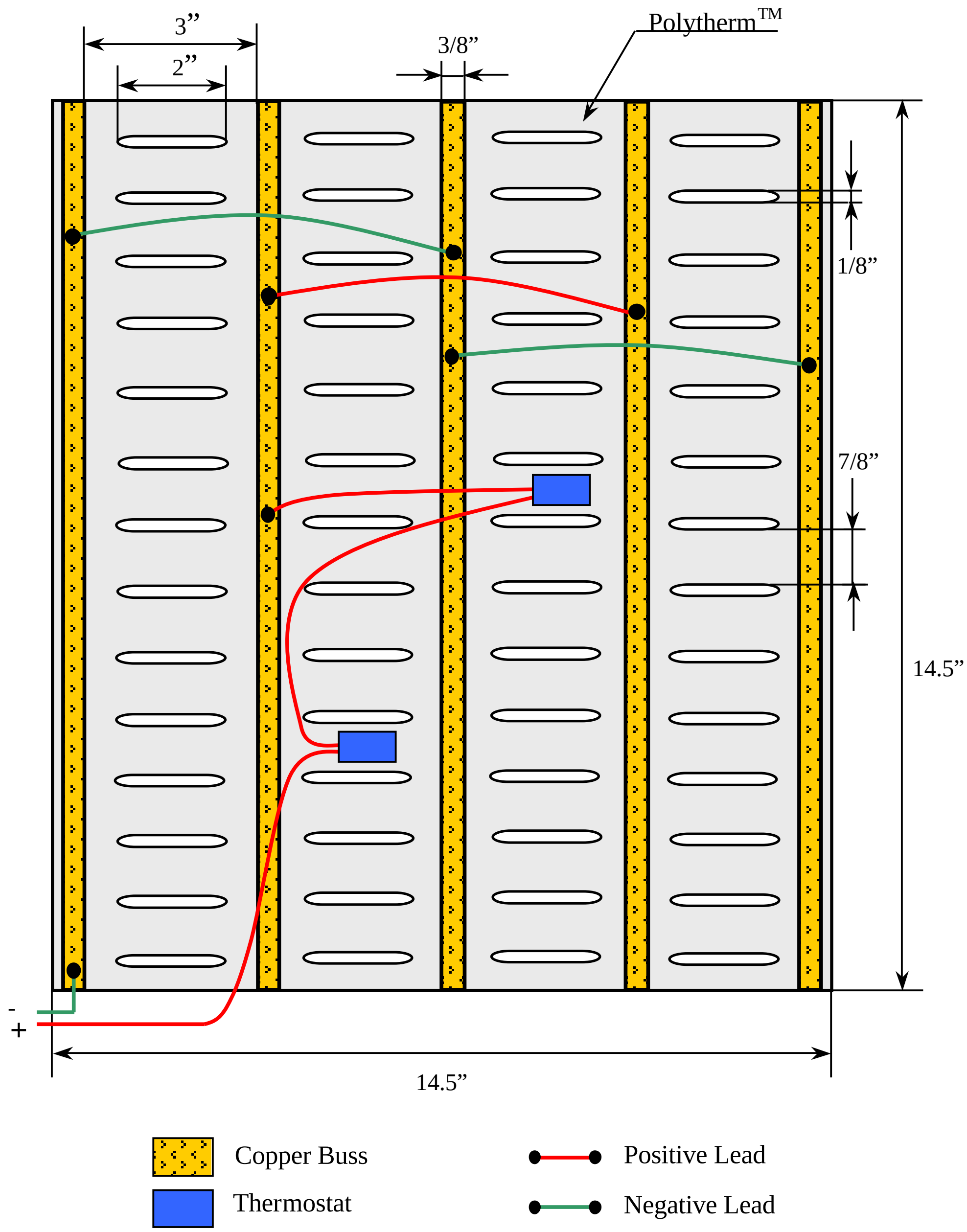


B. Case Components
The case — represents a real-life task, situation, or problem that sets the context for the case.
Problem Analysis — allows students to explore and define the problem. Students often work collaboratively here and engage in active discussions.
Field Insights — a wide range of expert 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.
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 in this case. That is, at any point in the execution of the case cycle, students can enter and explore any of these categories. The case may be considered a "module." In an ideal learning environment, multiple modules will be developed to support a larger objective or the "global Challenge." Cases 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.

V. Sample Case

The author has written and co-produced several cases, one of which is attracting the attention of various educators. It is based on the pizza warmer that the Electrical Product Division of Heatcraft in Murfreesboro, TN has developed. The material being used for the heating element is a revolutionary sheet of plastic impregnated with carbon-composition materials and is named Polytherm™. These sheets come in various thickness and widths. In the circuit analysis track of this case, the student is asked to model the pizza warmer's electrical circuit and solve for the resistance, current, power, and energy consumption. The case can also take various other tracks such as circuit design, thermodynamics/heat transfer, and/or business applications (engineering economy). The pizza warmer heating element is shown below.



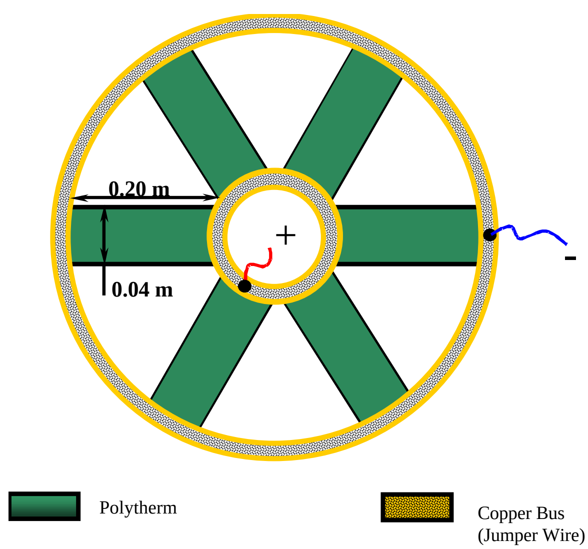
The case is entitled “I Want My Pizza Hot” with the following initial student objectives: Model a real electrical load into an electrical circuit; use critical thinking and apply basic algebra in problem solving; convert between systems of units; calculate the resistance of a material from its physical parameters; apply Ohm’s law in DC circuit analysis; calculate power and energy; conceptualize duty cycle and basic heat transfer; consider electrical safety measures; use spreadsheets, interpret data, and apply charting skills; use software to simulate electrical circuits; use oral and written communications skills to present data and conclusions.

The case includes an Instructor Guide that details a possible approach for conducting the case and helps instructors new to the case method. It also offers solutions to various questions and lists common student misconceptions. The author recommends the use of active collaborative learning when conducting the case. The student is led through the case to a series of events describing the design process of the pizza warmer and is asked questions that provoke critical thinking and logic reasoning and then is asked to solve the case in cooperation with his/her teammates. The student is also asked to find the resistance of the heating element of the warmer. The resistive element in this case has a non-conventional shape and is shown below. The complete case is available for field-testing and dissemination by contacting SEATEC at http://www.nsti.tec.tn.us/SEATEC/.

VI. Transfer Task Questions and Study Results

During the final exam, about two months after finishing the case, the students are asked to solve a series of questions to find the resistance of four different shapes: a cylindrical wire (conventional), a block of semiconductor, a thin carbon-fiber sheet, and a proposed satellite warmer made of Polytherm^{TM}, Fig. 1. The questions are distributed throughout the final. These text problems are not accompanied by 3-D figures that may help the student visualize current flow. After finishing this first part of the final and turning the answers in, a second set of three questions with 3-D figures were given to see if the student can be cued using visual aids as shown below in Figs. 2-4.

Fig. 1.



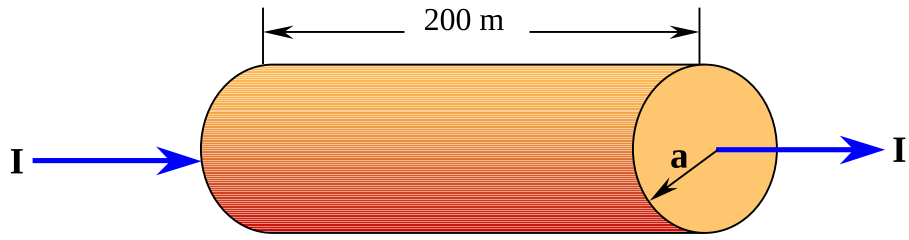


Fig. 2.

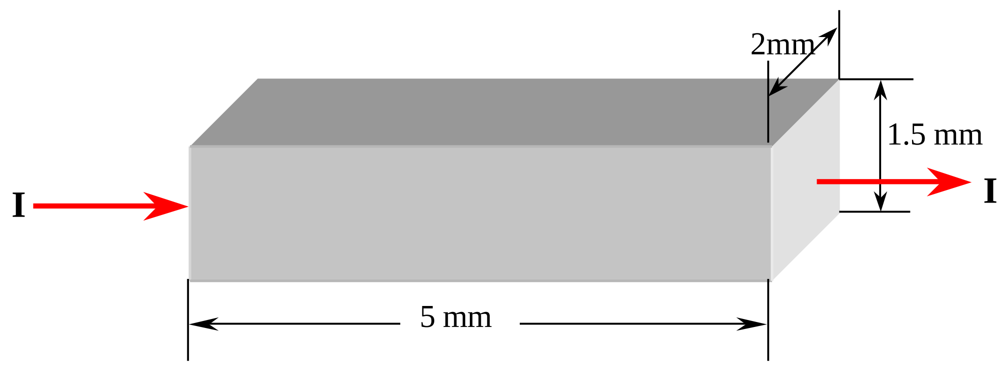


Fig. 3.

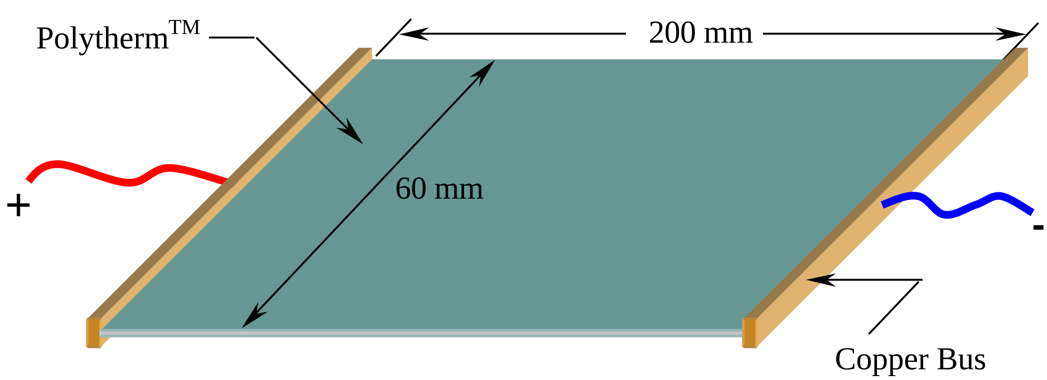


Fig. 4.

To assess the effectiveness of the case method, the author used other sections of the same class as "control" sections to compare results. The author taught all three sections and covered the same materials except that cases were not used in the control section. The preliminary results indicate that the case method has helped the students in applying what they have learned using the case to other resistor shapes and forms.

Results from the field-testing of the model case "I want My Pizza Hot!" over the past two years have indicated clear and significant improvements in students' performance in the case sections when compared to students' performance in the "control" sections where a "traditional" teaching environment was used.

VII. References

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