Innovations in Curriculum Integration, Delivery, and Assessment For Engineering and Technology Education

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Abstract

The current paper outlines an innovative approach to curriculum integration, development, and delivery that improve engineering and technology education and revive student interests in pursuing these programs. This is one of the objectives of the three-year NSF-funded grant titled "The South-East Advanced Technological Education Consortium, SEATEC." The consortium is a collaborative effort of five different teams across Tennessee. Each team includes multi-disciplinary faculties from two-year technical college, industry partners, four-year engineering technology university partners, and high school tech-prep teachers. A brief account of the grant's activities is described here and a sample case targeted for introductory courses in electrical circuit analysis is presented.

I. Introduction

The fast introduction of new technology in the workplace has greatly affected the daily operation of most industrial institutions. Automation, telecommunication, and computer applications have resulted in higher efficiency, reliability, and/or lower production cost. In face of this fact, however, companies currently encounter the new challenge of staying technologically current or risk falling behind the competition! On the other hand, the implementation of a new technology is often slowed down by the unavailability of skilled workers. Therefore, it is essential that entry-level technical employees possess the required skills in order to be productive as soon as they join the workforce.

In order to address the increasing demand for a skilled workforce, a process was needed for the development and dissemination of a technology-based education curriculum, which is both readily accessible and responsive to innovation and industry needs. As a result, a coalition of five two-year technical colleges in Tennessee with representatives from four-year universities, secondary schools, business and industry, and government institutions in Tennessee, Kentucky, and Alabama was formed in order to plan a solution. A grant proposal, titled "Tennessee Exemplary Faculty for Advanced Technology Education, TEFATE" was prepared, submitted, and funded by NSF for two years (1996-1998). The primary objectives of TEFATE were: developing a group of faculty who provide leadership in curriculum development in emerging technology fields and developing an understanding of the cross-disciplinary needs through successful team strategies. Activities to accomplish these objectives provided the participating faculty with experience in interdisciplinary team building, leadership, and active and cooperative learning while exposing them to the latest technological practices in the industry. The major outcome of this initial project was the development of twenty-five work-based case studies that are interdisciplinary and apply team building, and active learning approach. These cases are currently being field-tested, modified, and are available for further testing and review at: http://www.nsti.tec.tn.us/SEATEC.

II. The Next Step

With the success of the TEFATE approach to curriculum development, a follow-up three-year proposal titled "The South East Advanced Technological Education Consortium, SEATEC" was submitted and is currently funded by NSF. 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.

III. Work-Based Case-Study Approach to Curriculum Development

Case studies have been proven to be effective teaching tools in many fields ranging from business and finance to medical. They are usually based on real-world problems that students can easily identify with and allow students to use their critical thinking and logic reasoning abilities. Collaborative education and team concept can be used effectively in a 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. Finally, 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[1-3]. As a result, there is a growing need and interests in work-based case studies for engineering and technology education.

One of the greatest challenges that most students face during the course of their 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. In addition, team approach and active learning are not widely used in technical programs in the higher education. For this reason, many engineering and engineering technology students often find themselves frustrated and sometimes loose interest in pursuing their degrees in technical fields. Furthermore, students who finish their education may not be well prepared to face industrial challenges such as working in multi-disciplinary teams that deal with complex and open-ended situations.

To address this growing problem and in order to increase the number of students interested in technical fields and better prepare them to meet future challenges, 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 technology education. Models for the development and applications of case studies that are interdisciplinary, multi-media enhanced, open-ended, and use active collaborative learning are being developed, tested and disseminated nationally and internationally.

IV. Strategy to Achieve Objectives

In order to achieve the above set goals, several activities have been and are being conducted throughout this project. Some of the major activities are:

1. Leadership in Case-Based Technical Instruction

The faculty participating in the TEFATE and SEATEC projects had to go through rigorous training and professional development in preparation for the development and implementation of case studies in technology and engineering education. These activities include:

- Attending technical workshops and seminars.
- Computer based training, reading assignments, and visits to other universities.
- Team building, active collaborative education, and leadership training.
- Case study development and implementation.
- Applying multimedia in curriculum development.
- Industry site visits.
- Faculty internship in industry.
- Applying and field-testing case studies in technology programs.

In addition, two professional development forums titled “Characteristics of an Effective Case Study” and “Strategies for Using Case Studies in Teaching and Learning” were held at the Peabody College, Vanderbilt University last year. Two panels of nationally recognized case study experts who addressed questions and concerns regarding the use of the case study technique in technology education hosted each forum. The forums were followed by knowledge mining activities led by the Learning Technology Center[4] (LTC) at Vanderbilt in which SEATEC faculty members shared their ideas electronically with the experts, industrial partners, and other members. Finally, eight new model cases were presented at the 1999 Summer Workshop, which bore the fruits of this activity-filled year (few more cases are still being developed).

2. Professional Development for Faculty

In addition to the workshops and training sessions mentioned above, a Professional Development Team was formed and conducted campus-wide in-service sessions at the five participating institutions. These introduced participating as well as other faculties to the benefits of using case studies in technology education. In addition, numerous industrial site visits exposed the faculty to the latest technological practices in the area industry and provided the basis for new “real-world” based problems that will be used in case studies.

3. Assessment of the Case-Study Approach

The LTC at Vanderbilt was contracted to assess the effectiveness of the case study approach in teaching technology students. Twenty-five cases developed under the previous TEFATE grant were posted on the web and also printed for distribution across the globe. Each team identified courses where field-testing will be performed and assessments are being conducted. An advisory committee was also formed to monitor the progress in meeting this objective. Most of the cases developed under both grants have been field-tested. Surveys of faculty and students were conducted before, during, and after testing. Videotaping and outside monitoring were also used. Contents reviewing of cases by professional in the field are also being conducted. Initial assessments indicate very positive results.

4. Dissemination

SEATEC members have published several papers and presented at various international, national, and regional conferences and are disseminating the preliminary results of this grant. A web site has been also created to electronically disseminate materials related to the grant http://www.nsti.tec.tn.us/SEATEC/. Videotapes as well as other published materials are being also distributed to interested parties. TEFATE and SEATEC cases are published in the form of books and being distributed to various institutions.

V. Case Components

The initial key components that have been identified by the participating faculty and the team of experts are:

- A "set"—a brief story line intended to get the reader's attention and generate interest in the case itself;
- A background narrative—to provide a historical context and also situate the problem and the rest of the case in a real-world workplace context;
- A problem to solve, appropriate for the reader's situation, and which could be small and very specific or larger and more general—this is the issue that the reader must analyze to identify problems and develop solutions;
- Questions for the student to answer—to promote additional critical thinking and also to guide the analysis that the readers and student groups must conduct;
- An instructor's guide—to provide comprehensive support for the teacher through instructional strategies, possible solutions, alternative problems to solve, and tailored support material based upon the content areas and the intended student level of the problem and material contained in the case.

More recently, the teams agreed to adopt an additional checklist required for the model cases being developed in order to increase quality, consistency, and appropriateness for technology education. These include: student objectives, assessment tools and techniques, "Real-world" business applications, a mathematics component, a science component, technical writing and oral presentation components, a technical focus, identification of target audience, instructor's guide, suggestions for extending the case, and supporting materials. These model cases are also being further enhanced by the use of multi-media delivery systems.

VI. Sample Cases

The majority of the initial twenty-five cases developed under TEFATE can be implemented in the first two years of most engineering and technology schools. In particular, these cases were developed in order to address the need for improvements in the delivery system and curriculum contents of the fast changing and growing telecommunication field. Many of these cases can be used in introductory level circuit analysis, networking, information systems, and communication courses. The author have participated in the writing and development of several cases but most notably he has co-authored a short case based on a visit to the Sprint hub in Johnson City, TN. The student is asked in this case to configure the connection required for powering a system of 48-V telecommunication modules (one master and ten slaves) using 12-V batteries depending on currents and energy back-up requirements. The complete case titled “What Happens When the Lights Go Out? Can I Still Call for Help?” is available at the SEATEC web site: http://www.nsti.tec.tn.us/SEATEC.

The second case that the author has developed is attracting the attention of various educators. It is based on the pizza warmer that the Electrical Product Division of Heatcraft in Murfreesboro, TN is manufacturing. This pizza oven is currently being used by delivery drivers and at most take-out locations of a major pizza company and will be available to the public soon. The material being used for the heating element is a revolutionary sheet of plastic impregnated with carbon-composition materials and is called Polytherm™. These sheets come in various thickness and widths. The student is asked to model the warmer’s electrical circuit and solve the circuit to calculate resistances, currents, power, and energy consumption in an active collaborative learning approach. The case can also take various directions such as the business applications (engineering economy) and thermodynamics/heat transfer. The case is titled “I Want My Pizza Hot” with the following initial student objectives:

- Model an electrical circuit based on a real electrical load.
- 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 heating element is shown in Figure 1 and the complete case is available for field-testing and dissemination from the SEATEC website.

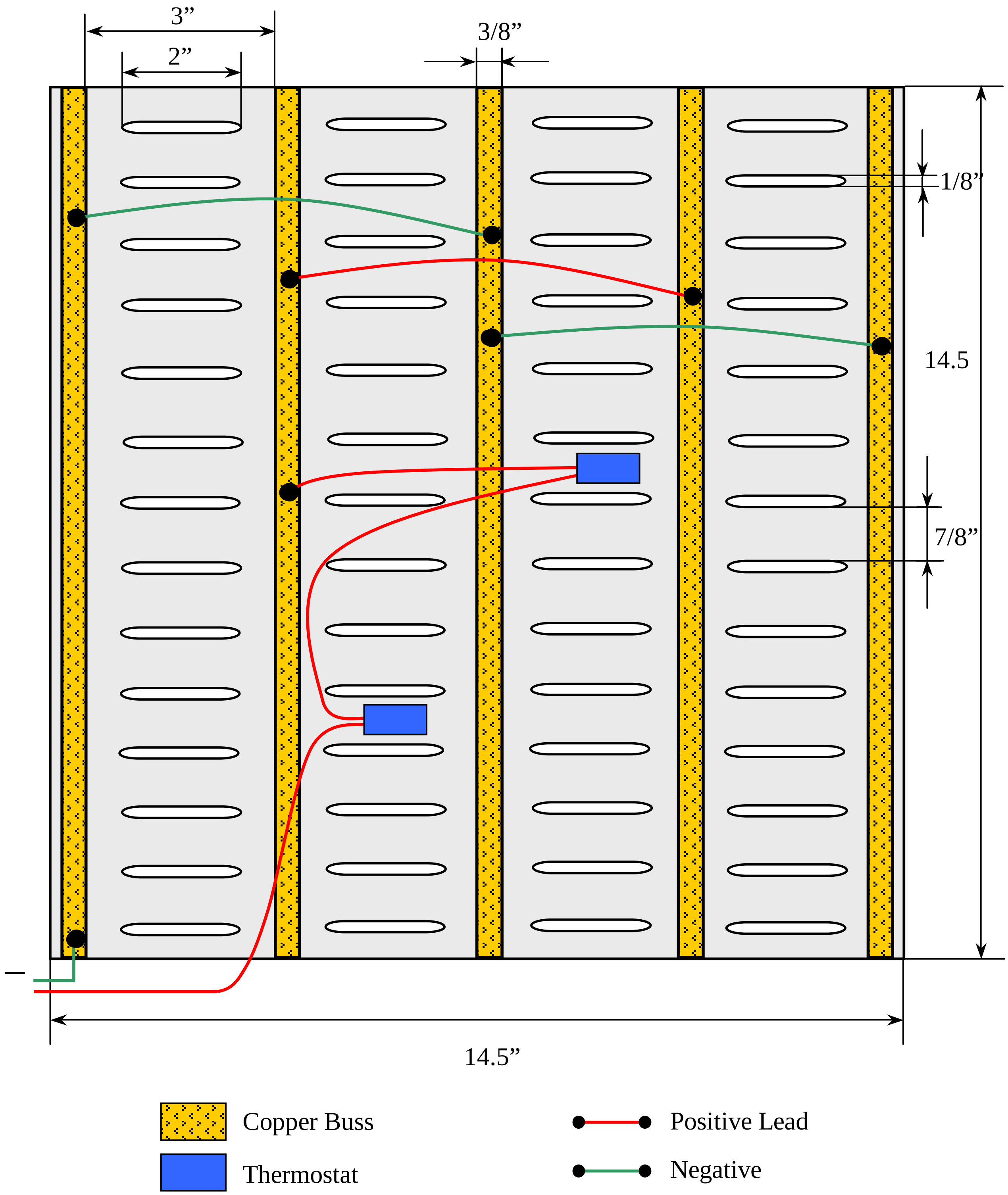

Figure 1. Polytherm™ Pizza Warmer Heating Element.

VII. Summary

Improvements in curriculum development, implementation, and delivery targeting engineering and technology education have been made through two consecutive NSF-funded grants titled TEFATE and SEATEC. The unique industrial partnership with higher education institutions participating in these two grants has benefited both systems by training faculty to identify technical needs, upgrading curriculum to meet those needs, producing work-based real problems that use cooperative learning and team building concepts, improve student verbal and written communication sills, and ultimately producing better prepared graduates that can meet today's emerging technological challenges. The results of the grants are also being disseminated globally.

VIII. Acknowledgments

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IX. References

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Dr. Saleh M. Sbenaty is currently an Associate Professor of Engineering Technology at Middle Tennessee State University. He received the BS degree in Electrical Engineering from Damascus University, Syria and the MS and Ph.D. degrees in EE from Tennessee Technological University. He is the current team leader of the Nashville Tech. team and actively engaged in curriculum development for technology education. He has written and co-authored several case studies. He is also conducting research in the area of mass spectrometry, power electronics, lasers, and instrumentation.