APPLYING CASE STUDIES IN ENGINEERING TECHNOLOGY COURSES*

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ABSTRACT

In 1996, five Tennessee technical community colleges received funding for a National Science Foundation Advanced Technology Education (NSF/ATE) project. The purpose of the project was to develop a group of faculty who will provide leadership in telecommunications curriculum development. Two of the goals of the project were to 1) develop a framework for a telecommunications curriculum and 2) develop thirty case studies that focus on real world problems in the telecommunications industry. A team of cross-disciplinary faculty developed a case study format appropriate for technical courses. Information about actual industrial problems was gathered by visiting companies and discussing with key personnel the issues facing technicians in telecommunications. Then five sample case studies were developed.

INTRODUCTION

Using structured case studies to introduce real world applications is popular and successful in business related programs. Presently, professors in engineering technology programs make little use of structured case studies. Is there a way to successfully implement case studies into an engineering technology curriculum? If so, what format should be used and what are the essential elements of the solid case study?

A case study is a method of involving students in real life scenarios. Because engineering technology courses are application oriented, case studies are a natural fit. Many engineering technology textbooks have word problems at the end of each chapter. Typically, an instructor will present principles in the classroom, demonstrate how to apply these principles to sample problems, then assign students similar problems for homework. The next class period, problems are reviewed and students ask questions to be sure that problems are correctly worked. This process of problem solving has its place. But, word problems segment knowledge and are not typically based upon a real world application. Case studies differ from word problems in that cases are based upon real industrial problems and the approach is holistic. Does this mean that case studies should replace word problems? No, case studies should be utilized to augment the current instructional process to bring real life scenarios to the classroom.

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What is the structure and content of an effective case study for engineering technology courses? Answering this question was one of the objectives of a cross-disciplinary team of faculty members participating in a NSF/ATE funded project. This paper presents the process by which this objective was accomplished.

SEATEC

The Southeast Advanced Technology Education Consortium (SEATEC) was established to create a network of institutions to combine their resources in the pursuit of continuous improvement in engineering technology programs. The members of SEATEC are Chattanooga State Technical Community College (CSTCC), Jackson State Community College (JSCC), Nashville State Technical Institute (NSTI), Pellissippi State Technical Community College (PSTCC), and State Technical Institute at Memphis (STIM).

The National Science Foundation's Advanced Technological Education program (NSF/ATE) has provided the basis for the consortium's activities. The overall goals of SEATEC are (1) to reduce the lag time between the identification of emerging technology and the implementation of curricula in two-year colleges and secondary schools; (2) to strengthen and continuously improve existing and new engineering technology curricula; (3) to provide faculty training and development; (4) to develop and enhance strong linkages between colleges and universities, secondary schools, business and industrial organizations, and government agencies; and (5) to promote minorities and women in the fields of engineering technology.

To provide a model for consortium activities, SEATEC members identified telecommunications as an emerging and dynamic technology lacking sufficient curriculum development and as a discipline appropriate for training and developing faculty. The first NSF/ATE funded project of SEATEC focused on curriculum and faculty development and is called the Tennessee Exemplary Faculty for Advanced Technological Education (TEFATE).

TEFATE PROJECT

TEFATE is based on the South Carolina Exemplary Faculty for Advanced Technological Education project and is in response to the Secretary's Commission for Achieving Necessary Skills (SCANS) report which states, "*We believe, after examining the findings of cognitive science, that the most effective way of teaching skills is 'in context'. Placing learning objectives within real environments is better than insisting that students learn in the abstract what they will then be expected to apply.*" The TEFATE project used a holistic approach to curriculum development in support of the growing telecommunications technology industry. Interdisciplinary teams composed of academic partners and industrial partners from across the state of Tennessee and southeast region are implementing the project (see Appendix A for a list of participating members). The success of the project was due in large part to these partnerships.

The primary goal of this project was to develop a group of faculty who will provide leadership in telecommunications curriculum development. A secondary goal of the project was the development and dissemination of a clearly defined curriculum framework for telecommunications technician education at the Associate Degree level. This curriculum includes the development of case studies to present work-based applications for use in classroom activities.

CASE STUDY FORMAT AND APPLICATION

At a TEFATE workshop in June 1997, a cross-disciplinary team of faculty members developed a format for an engineering technology case study. The team was broad-based and consisted of university, community college, and secondary instructors from engineering technology, English, mathematics, and science disciplines. First, the team reviewed the current literature about case studies as a way to define a case study. Then the team evaluated four business - related case studies to identify common elements between the case studies. Next, the team developed guidelines necessary for an engineering technology case study.

A case study should consist of at least the following five components:

1. The Set
2. Background
3. Problem
4. Questions
5. Instructors Guide

The set is used to grab the reader's attention. It should lead the reader to the background of the problem.

The background introduces detailed information about the company, players, and/or technology. It sets the proper context for the presentation of the problem. The background information should be minimal but sufficient enough for the reader to make connections with the problem description.

The problem section describes the scenario, problem, or situation to be analyzed. This section would normally be longer than the background and should be integrated with the background information. Several forms for presenting the problem can be used. Examples of form are: a) multiple parts meaning a cross-discipline approach, b) technical narrative to support questions, and/or c) open-ended statements.

The questions are to stimulate the student's critical thinking processes. They provide the reader with direction toward logical, justifiable solutions. The questions should fit into the critical questioning hierarchy within the instructional design model; the hierarchy is sequence, comparison, classification, induction, deduction, error analysis, support construction, abstraction, and perspective analysis.

The instructor's guide should include many of the following elements:

- a. Overall purpose
- b. Learning objectives
- c. Solutions or guidelines to finding solutions
- d. Additional resources (bibliography)
- e. Reference to course competencies/skills and disciplines
- f. Alternative approaches
- g. Approach to the case study analysis using the critical thinking model
- h. Student report format

This format was applied to the development of case studies at the 1997 TEFATE workshop. These case studies were based on information provided in previous industry site visit reports. From this beginning, a word-processing template was designed to standardize the creation process. A sample case study can be found in Appendix B. This case study and others have been used in classroom settings at Chattanooga State and Jackson State. The response from professors and students is very positive with a strong indication that case studies should be used more frequently.

An important key in making an effective case study is that a case should be based upon a real industrial experience (Camerius). This happens to be the most difficult part of developing a case because it takes time to identify an appropriate problem, accurately document the problem and the solution, and gain permission from a company to use the problem in a public case study. Using members of technical advisory committees can help with this process as well as faculty from other disciplines.

The next most difficult part of case development is writing questions that take the students beyond a surface analysis of the problem. Those writing a case study need to incorporate concepts and practices of critical thinking into the questions. Writing questions that stimulate student's critical thinking skills takes creativity, patience, and faculty critical thinking. The Dimensions Matrix developed by Dr. Mary Ann Blank of the University of Tennessee can be a helpful tool when developing questions with a higher order of thinking.

Another aspect to consider when writing case studies is that revisions to cases will be necessary once student feedback has been obtained.

CONCLUSIONS

Case studies can be used to provide real-world scenarios for students in an engineering technology curriculum. A format for developing a case study can provide a structure in which to build an effective case. When developing a case study, real industrial problems should be identified. The work required to develop a case is time consuming. But, the use of cases in engineering technology courses can better prepare students for the real world of work thus giving them a competitive edge in the job market.

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BIOGRAPHICAL INFORMATION

James L. Barrott is presently serving as the Dean of Engineering and Environmental Technology at Chattanooga State Technical Community College. He teaches courses in the Mechanical Engineering Technology and CAD/CAM Technology programs. He is a co-Principal Investigator for SEATEC and TEFATE – NSF Advanced Technology Education funded projects.

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APPENDIX A - TEFATE Team Members

SEATEC Members	University Partners	High School Partners	Business Partners
NSTI			
Sydney Rogers, Dean of Technologies	Peter Romine, Engineering Tech.	Michael Crick, Vocational Tech.	Ronnie Johnson, Manager
And TEFATE Project Director	Alabama A & M University	Hillwood High School	Columbia/HCA Healthcare Corp.
Kurt Frederick, Grant Admin. Assistant			
Collin Balance, Grant Evaluation			
Ted Washington (PI), Head of CIS			
Charles Hoover, Computer Tech.			
Cindy Greenwood, Computer Tech.			
Claudia House, English			
Charles McSurdy, Math			
CSTCC			
James Barrott (PI), Dean of Engr. and Env. Tech.	No Participant Available	David Kindiger, Guidance Counselor at	James Hyatt, Elect. Engineer
Wayne Jones, E.T.		Red Bank High School	with Tennessee
Richard Seehuus, English			Valley Authority
Theresa Underwood, Math/Sciences			
Jo Ruta, Business & Info. Systems			
JSCC			
Neal Jackson (PI), Dean of Career Studies	William Call, E.E.T.	Roy Weaver, Vo-Tech Director	John Bentley,MIS Manager
Mel Montgomery, E.E.T.	Murray State University	Jackson/Madison Cty. Schools	Touchstone Corporation
Susan Randolph, Math			
Doug Teague, Business			Bill Montgomery
Linda Theus, Chair of CIS			Dir. Engr.
Mark Walls, English			Digital Telecom.
PSTCC			

Lisa Bogaty (PI), Director of New Programs	William Hemphill, M.E.T.	Nancy Witick, Lab Supervisor	C.J. McKinnis, Acct. Manager
Gail Burris, Assistant Professor	David Tarnoff, E.E.T.	Farragut High School	Sprint Corporation
Don Coffman, Elect. Engineering	East Tennessee State University		
Karla Foss, Coordinator Tech. Math			Jim Snyder, V.P. Bus. Dev. Tech 2020
Gay Lyons, English	Saleh Sbnaty, E.T.		
	Middle Tennessee State Univ.		
STIM			
Margie Hobbs (PI), Professor of D.S.	Deborah J. Hochstein, M.E.T.	Le Duckworth, Curric. Coordinator	Bob Allen, Sen. Engr. Ops. Mgr.
Dean Honadle, Telecommunications	The University of Memphis	Memphis City Schools	Time- Warner Communications
Marguerite Jackson-Jones, Dev. English			
Lisa Rudolph, Information Tech.			Ray Ebner, Operations Mgr.
Colathur Vijayan, Math			MCI Telecommunications Corp.

APPENDIX B - Sample Engineering Technology Case Study

Physics — Algebra — Electronics — Technical Writing

National Science Foundation

This case study was produced by the
Jackson State Community College
TEFATE team and supported by a grant
from the National Science Foundation.

CASE STUDY

SEATEC

Connecting the world through technology education

Transmission Line Fault Location

Student Objectives:

- apply basic principles of signal propagation through cables
- observe good troubleshooting principles
- utilize algebra and physics in data communications troubleshooting
- use basic electronics test equipment
- practice technical writing

Bill looked up from his workbench in the electronics shop to see Joe, the college's head electrician, walk in, followed by Dan, the Director of the Computer Center.

"Oh-oh. There must be trouble somewhere for you two to visit like this," Bill said, greeting them.

"Yep," replied Dan. "We know you always enjoy a challenge, and we have a good one for you. We've got to have a remote computer terminal working by tomorrow over in the Student Center, and we just found out that it doesn't work. The setup worked fine last semester, but when we plugged everything up to the underground data cable there was no response this time. We know the terminal equipment is good because it works fine using a different data cable to another building. Joe thinks the underground cable has been cut or broken somehow.

> ***"I can't figure any way to determine where the break in the cable is without digging up the whole 800-plus feet of cable, and we don't have time for that! . . . If we could just know where to dig, we could splice the break in time. Is there any way you could figure where the problem is?"***

"How have you determined that, Joe?" Bill asked.

"By using an ohmmeter and a terminating resistor at the far end," Joe replied. "I figure the cable has been cut and the little continuity that we do see is due to moisture in the ground supplying a poor path across the ends of the wire. But I can't figure any way to determine where the break is without digging up the whole 800-plus feet of cable, and we don't have time to do that. Besides, that would make a real mess, and my boss would have a fit! If we could just know about where to dig, we could splice the break in time. Is there any way you could figure where the problem is?"

The Problem

Bill thought for a minute. He knew that if the line had a dead short, he could make a rough guess using an ohmmeter and the measured resistance from each end; but with an open, the results wouldn't be precise enough for a determination. But there was a way to answer the challenge: send a pulse of current down the cable, and measure the time required to see the "reflection" of the pulse come back to the source after it encountered the broken end of the cable. The concept is called ***Time-***

QUESTIONS

1. **Explain how Joe used good troubleshooting principles to narrow his problem to the buried cable.**
2. **Explain how Joe knew the cable was open using an ohmmeter.**
3. **Why couldn't the location of the fault be accurately determined with an ohmmeter?**
4. **If the cable fault had been a dead short, how could an ohmmeter be used to determine an approximate location?**

QUESTIONS

5. **Suppose the velocity factor of the cable is unknown. How could the problem be solved if another piece of cable, of known length, is available?**

6. **Suppose the velocity factor of the cable is unknown and no other cable is available for comparison, yet both ends of the cable are accessible and its length is known. How could the distance to the fault be found?**

7. **Draw a diagram illustrating Bill's equipment setup and the cable-fault situation.**

8. **Verify Bill's result of 390 feet with your own calculations.**

9. **Reduce the calculations required in case this were to be solved repeatedly; i.e. derive a simple formula that gives the distance to a fault in feet if the velocity factor of the cable and the total pulse travel time, in microseconds are known.**

10. **Suppose you are Joe and your boss tells you not to dig up the new sidewalk unless you can prove to him the problem is there. Write a memo to the Director of Buildings and Grounds explaining your determination. Use technical facts to justify your position, but explain things in a way a non-technician can understand.**

Transmission Line Fault Location

Domain-Reflectometry: just as a ball bounces off a wall or a beam of light off a mirror, a pulse of current will "bounce back" from an open or shorted transmission line (there's no reflection from a properly terminated line). If the Velocity of signal travel in the cable is known, and the travel Time can be measured, then calculating the Distance can be done using the familiar **d = v • t** formula. Fancy instruments are available to do this directly, but the college didn't own a Time-Domain-Reflectometer, so something would have to be improvised.

"Ok," Bill replied. "I can do it. Help me carry the pulse generator and oscilloscope over to the Computer Center."

Once there, Bill connected the pulse generator to the cable's connector and hooked the oscilloscope across the same point using a "Tee" and short leads. He set the generator to send a very fast-moving 5-volt pulse down the cable. Sure enough, the oscilloscope showed the initial pulse followed by a strong reflection of nearly the same amplitude in 1.2 microseconds. Pointing to the reflection, Bill announced, "there's the problem, just 1.2 microseconds away!"

"How far is that in feet?" asked Joe.

Bill grinned. "I thought you would want to know that! Well, we know that signals in wires travel somewhat slower than the speed of light; in fact, every cable has a "velocity factor" that gives its speed rating as a percentage of **c**, the speed of light, which is 186,300 mi./sec. This is standard Ethernet cable with a velocity factor of 66%.

Bill whipped out his pocket calculator.

"We have to convert the miles/second to feet/second by multiplying by 5,280 feet per mile. Also, the distance to the fault is found by using half the measured time on the 'scope, since the pulse has to travel that distance twice, both down and back."

After punching in the numbers, Bill announced, "that means your fault is about 390 feet from here."

Joe pulled out his map of buried cables on campus and studied it closely, figuring out where 390 feet would be. Suddenly, he snapped his fingers.

"I know! That's right where the grounds crew replaced a section of broken sidewalk last month! They must have dug too deep and cut the cable!"

"Let me know if that's what you find," Bill said, packing up the equipment.

Two hours later, Bill's telephone rang.

"I'll buy you a cup of coffee tomorrow morning," Dan said. "That was it, and the problem is repaired!"

Physics — Electronics — Algebra — Technical Writing

National Science Foundation

This case study was produced by the
Jackson State Community College
TEFATE team and supported by a grant
from the National Science Foundation.

CASE STUDY

Transmission Line Fault Location

Instructor's Guide

Student Objectives:

- apply basic principles of signal propagation through cables
- observe good troubleshooting principles
- utilize algebra and physics in data communications troubleshooting
- use basic electronics test equipment
- practice technical writing

Purpose of Case Study:

- to reinforce the principles of signals propagating down a cable with a practical example
- to show how basic principles lead to practical application in troubleshooting network problems
- to practice math and physics principles

QUESTIONS	SOLUTIONS
1. **Explain how Joe used good troubleshooting principles to narrow his problem to the buried cable.**	By moving the equipment to another cable and finding that the equipment worked on the other cable, the problem is reduced to just the first cable (assuming intermittent problems aren't a factor, cable lengths and quality are comparable, etc.). Also, since the cable under suspicion worked previously, it is probable that its original design was satisfactory and that some new fault has occurred.
2. **Explain how Joe knew the cable was open using an ohmmeter.**	With a 50-ohm terminator across the remote end, a good cable's resistance as measured with an ohmmeter should be 50 ohms plus the cable wire resistance, which can be found in reference manuals or simply estimated to be a few ohms (less than 50 ohms, certainly). A shorted cable would read less than 50 ohms. An open cable would ideally read infinite ohms, but moist soil can provide a path of a few hundred thousand ohms.

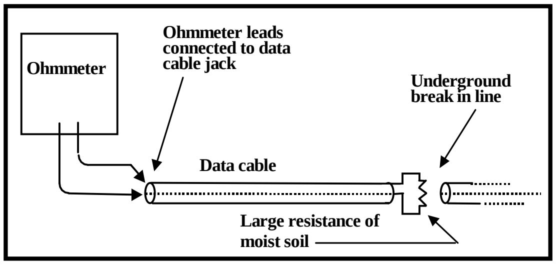

Figure 1. Ohmmeter/Cable Connection

Transmission Line Fault Location

QUESTIONS

3. Why couldn't the location of the fault be accurately determined with an ohmmeter?

Theoretically, if one knew accurately the soil resistance, that value plus the wire resistance would provide a method of estimating distance to the fault. However, the soil resistance isn't accurately known and, in fact, will likely change as ohmmeter current causes migration of copper ions from the end of the wire through the soil! Even if that weren't a factor, a few hundred thousand ohms of soil resistance compared with a few ohms of wire resistance would produce a meaningless difference.

4. If the cable fault had been a dead short, how could an ohmmeter be used to determine an approximate location?

Measure the resistance at the connector and, using wire data for the resistance per foot of the cable, calculate the distance to the short. In practical terms, this is often an imprecise technique, as "dead shorts" of zero ohms resistance are rare. Or, measure the resistance from each end; the distance from each end to the short is proportional to the resistance measured.

5. Suppose the velocity factor of the cable is unknown. How could the problem be solved if another piece of cable, of known length, is available?

First, send the pulse down the cable of known length, leaving its end open, and observe the reflection time on the scope. Solve the equation (solution for Question 9) for VF and use that value in the solution of the problem.

6. Suppose the velocity factor of the cable is unknown and no other cable is available for comparison, yet both ends of the cable are accessible and its length is known. How could the distance to the fault be found?

Measure the time from each end connector for the reflection. Each time will be proportionally the distance to the fault, or, from the first end, the distance to the fault is $\mathbf{D_1 = L \times \frac{T_1}{T_1 - T_2}}$

7. Draw a diagram illustrating Bill's equipment setup and the cable fault situation

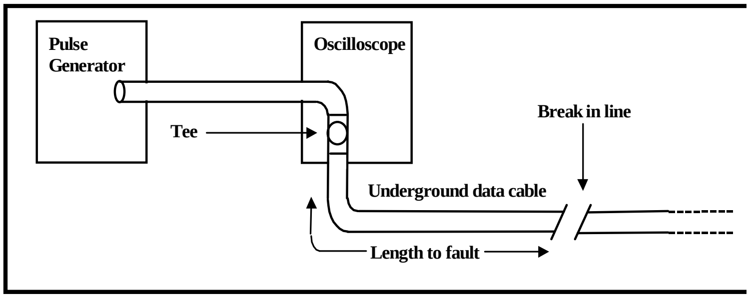

Figure 2. Equipment setup/fault situatio

8. Verify Bill's result of 390 feet with your own calculations.

$$\mathbf{D} = \mathbf{V} \times \mathbf{T} = VF \times \mathbf{c} \times \frac{T_{total}}{2} = .66 \times 186300 \frac{mi}{sec} \times 1.2 \times 10^{-6}\, sec \times 5280 \frac{ft}{mi} = 390\ ft$$

9. Reduce the calculations required in case this were to be solved repeatedly; i.e. derive a simple formula that gives the distance to a fault in feet if the velocity factor of the cable and the total pulse travel time, in microseconds are known.

$$\mathbf{D} = VF \times \mathbf{c} \times \frac{T_{total}}{2} = VF \times 186300 \frac{mi}{sec} \times \frac{T_{total}}{2} \times 5280 \frac{ft}{mi} \times \frac{1\ sec}{10^6\ microseconds}$$

$$\mathbf{D}\ (ft) = 492 \times \mathbf{VF} \times T_{total}\ (usec)$$

Transmission Line Fault Location

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