Dissemination of Innovations from an Educational Research Project through Focused Workshops[1]

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Abstract

During 1996, the Laboratory for Innovative Technology and Engineering Education (LITEE) was created at Auburn University. The mission of the laboratory is to develop and disseminate innovative instructional materials that bring real-world issues into classrooms, using multimedia information technologies and cross-disciplinary teams. We have developed seven multimedia case studies in partnership with industries in the region to bring real-world engineering problems into classrooms. The case studies illustrate in detail how an industrial problem is analyzed and a solution found. The format chosen by us enables the students to experience a real problem, develop a solution, and then compare their proposed solution with what was actually done.

These innovative educational materials have received several awards, including the Thomas C. Evans, Jr., Instructional Unit Award from the ASEE Southeastern Section, the Premier Award for Excellence in Engineering Education Courseware awarded by NEEDS, and the ASME Curriculum Innovation Award. In order to disseminate these materials to other faculty, we initially utilized conventional methods such as presentations at conferences, publications in journals, and marketing the materials through a traditional publisher. However, we found that these methods were not reaching engineering educators. This realization seems to corroborate the analysis reported in the NSF Report on the Evaluation of the Instructional Materials Development (IMD) Program. This report states that large publishers and professors tend to shy away from reform-oriented instructional materials because they are new and controversial and that a major barrier faced by the developers is the perceived absence of a market for reform-oriented materials.

We then developed a focused workshop, with the pilot session held during May 2000, with the assistance of sponsorship from the National Science Foundation to provide faculty with an opportunity to gain hands-on experience using our multimedia case studies. This workshop was very successful, and the evaluation results encouraged us to offer additional workshops during 2001 and 2002. The feedback and evaluations from these workshops have been extremely positive, and we have now formed partnerships with faculty members in several universities in order to disseminate these educational materials. The participants enjoyed the program, facilities, and energy and excitement of workshop members; and they felt that the workshops were unique and important in disseminating the type of innovative instructional materials that can bring real-world issues into classrooms. We conclude that focused workshops are an excellent means of disseminating innovative educational materials developed by faculty.

1. Introduction

A paradigm shift is taking place in engineering and technology education driven by the National Science Foundation (NSF), the Accreditation Board for Engineering and Technology Education (ABET), the changing expectations of employers, new developments in the art of pedagogy, and many other forces. Teaching success in today's world requires a new approach to instruction, and an important part of the new approach is the switch to inquiry-based student-centered learning (Smith, 1999). The new approach requires faculty to believe and affirm that every student can learn and model good practices that increase learning. Teachers should start with the student's experience but have high expectations within a supportive climate, building inquiry, a sense of wonder, and the excitement of discovery plus communication and teamwork, critical thinking, and life-long learning skills into learning experiences (National Science Foundation, 1996).

How has the education establishment reacted to the need for educating engineering students using this approach? The National Science Board stated that the number of science and engineering students is dwindling and the shortage of technically skilled workers is very high (National Science Board, 2000). U.S. universities lose 40% of freshman students admitted to engineering programs by the end of their sophomore year, and employers chide schools for not providing the skills that are needed by industries (Prados & Proctor, 2000). These observations show that the education establishment is not doing an adequate job of educating engineering students. This situation, in our opinion, is because appropriate educational materials that bridge the gap between theory and practice are not available to educators.

During 1996, we formed the Laboratory for Innovative Technology and Engineering Education (LITEE) in an attempt to address this problem. The mission of the laboratory is to develop and disseminate innovative instructional materials that bring real-world issues into classrooms, using multimedia information technologies and cross-disciplinary teams. Working closely with our industrial partners, we have developed seven multimedia case studies that bring real-world engineering problems into the classroom. The case studies illustrate how a problem in an industry is analyzed and solved. The format chosen by us enables the students to experience the problem in a realistic way, develop a solution, and then compare their proposed solution with the solution actually selected.

In order to disseminate these materials to other faculty, we initially utilized conventional methods such as presentations at conferences, publications in journals, and marketing the materials through a traditional publisher. However, we found that these methods were not reaching engineering educators. This realization seems to corroborate the analysis reported in the NSF Report on the Evaluation of the Instructional Materials Development (IMD) Program. This report indicated that large publishers and professors tend to shy away from reform-oriented instructional materials because they are new and controversial and that a major barrier faced by the developers is the perceived absence of a market for reform-oriented materials.

Therefore, we developed a focused workshop, with the pilot session held during May 2000, with the assistance of sponsorship from the National Science Foundation to provide faculty with an opportunity to gain hands-on experience with the use of our multimedia case studies. This workshop was very successful, and the evaluation results encouraged us to offer additional workshops during 2001 and 2002. The feedback and evaluations from these workshops have been extremely positive, and we have now formed partnerships with faculty members in several universities in order to disseminate these educational materials. In this paper, we share our experience of running these focused faculty workshops and discuss the evaluations and feedback received from the participants. We conclude that focused workshops are an excellent means of disseminating innovative educational materials developed by faculty.

Section 2 discusses the innovative educational materials developed at LITEE and provides an example of a case study – Design of Field Joint for STS 51-L: Launch Decision. This section provides the results of an evaluation when this case study was administered in engineering classrooms and describes how the instructional materials meet the needs of the new educational paradigm. Section 3 lists the different mechanisms used to disseminate this case study and others to engineering educators and focuses on the selection of the focused workshop as one of the effective methodologies. Section 4 gives a detailed description of a focused workshop and shows how both 4-year and 2-year engineering educators receive hands-on training using the innovative materials. Sections 5, 6, and 7 provide the results from the evaluation of the focused workshops. Section 8 summarizes and concludes the paper.

2. Innovative Educational Materials Developed at LITEE

The instructional methodology used consisted of (a) developing a series of written case studies in conjunction with industrial partners, (b) adding competency material on engineering and business topics that students may use for reference, (c) creating multimedia versions of the case studies, (d) administering the case studies in engineering classrooms, and (e) evaluating the effectiveness of the case studies in achieving the goals and objectives. We discuss each of these items in this section.

(a) Developing a Series of Case Studies

So far, we have developed the following case studies:

(a) Design of Field Joint for STS 51-L: Launch Decision
(b) Della Steam Plant Case Study
(c) Crist Power Plant Case Study
(d) Chick-Fil-A Case Study
(e) Aucnet USA Case Study
(f) In Hot Water: A Cooling Tower Case Study
(g) Powertel: Wireless Cell Tower

To provide an example, we will discuss one of the case studies in detail: Design of Field Joint for STS 51-L. The case study was developed so that it traced the technical, business, ethical, and managerial issues that were debated and resolved in the design of the field joint of the solid rocket motor over the period 1971 to 1986. We describe subsequently the major events that have been covered in this case study (Sankar et al., 2000; Vaughn, 1997). A slide highlighting the important aspects of this case study is shown in Figure 1.

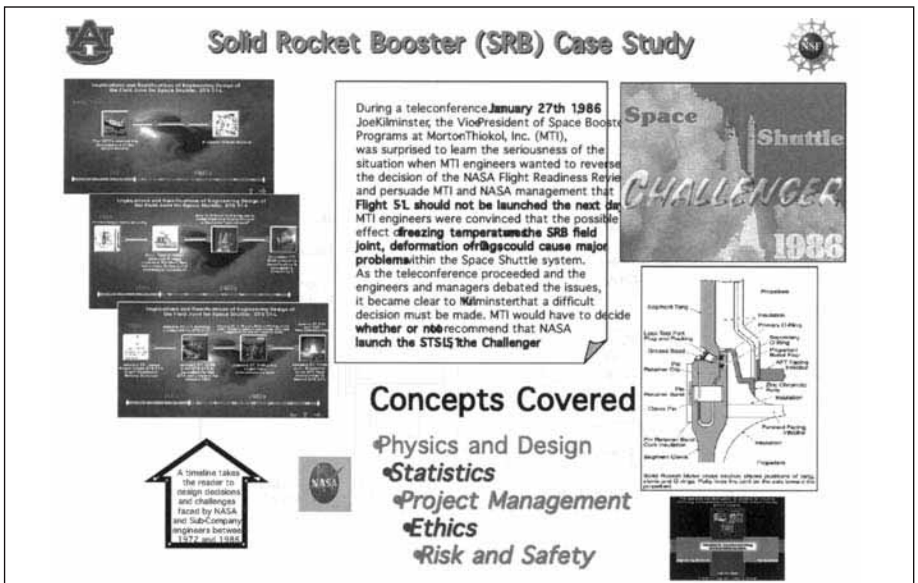


Figure 1

Overview of the Case Study

Joe Kilminster, the Vice-President for Space Booster Programs at Morton Thiokol, Inc., flipped the teleconference switch in the MTI conference room on January 27th, 1986. MTI had successfully created the Solid Rocket Booster, the first solid fuel propellant system, for the NASA Space Shuttle, and it had worked without fail in all 24 Shuttle launches to date. Although MTI and NASA had encountered problems with the Solid Rocket Booster field joint in the past, these seemed resolved when larger O-rings and thicker shims had been instituted. Thus, during the teleconference on January 27th, Mr. Kilminster was surprised to learn that MTI engineers wanted to reverse the decision of the NASA Flight Readiness Review and persuade MTI and NASA management that Flight 51-L should not be launched the next day. MTI engineers were convinced that the possible effect of freezing temperatures on the SRB field joint could cause major problems within the Space Shuttle systems. As the teleconference proceeded and the engineers and managers debated the issues, it became clear to Mr. Kilminster that a difficult decision must be made. MTI would have to decide whether or not to recommend that NASA launch the STS 51-L, the *Challenger*. The events that led to the decision are detailed in the case study and are summarized subsequently.

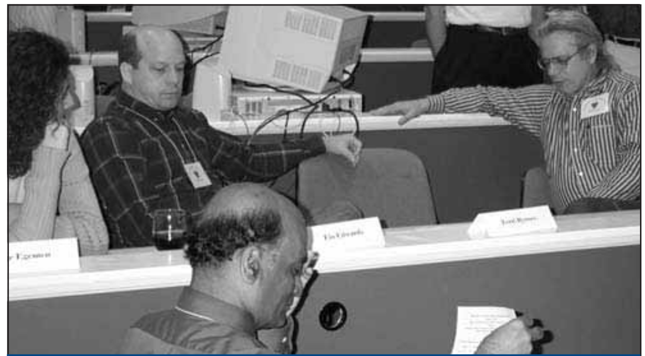
Testing of Solid Rocket Motor

During 1970-1977, Morton Thiokol, Inc. (MTI) used many tests including joint lab tests, structural test articles, seven static firings, and two case configuration burst tests to verify the performance of its product, the Solid Rocket Motor.

Leon Ray's Recommendation

In 1977, Leon Ray had recommended several solutions to fixing the joint rotation problem in a memo. He recommended that one of the following options be implemented:

1. No change
2. Shims between tang and clevis
3. Oversized O-rings
4. Redesign tang and reduce tolerance on clevis
5. Combination of redesign (Option 4) and use of shims



Participants working in teams on the case study project.

Design Option Chosen During 1980

At the completion of satisfactory tests, engineers at Marshall and Thiokol unanimously agreed that, although the performance of the field joint deviated from expectations, it was an acceptable risk. In 1980, with the approaching launch of Columbia, Marshall and MTI decided that, instead of redesigning the entire joint to solve the joint rotation problem (Option #4 in the Leon Ray memo), they would use thicker shims (Option #2) and larger O-rings (Option #3) on current hardware, and all new hardware would be redesigned. However, a redesign was not sanctioned until 6 years later. Therefore, all SRBs used between 1980 and 1986 had the 1977 field joint design with thicker shims and larger O-rings.

O-Ring Erosion and Putty

Between 1980 and 1984, the O-ring erosion/blowby problem was infrequent. However, the erosion on STS 41-B, launched on February 3, 1984, was more severe and caused concern among Marshall and Thiokol engineers. Although erosion was a problem, Marshall and Thiokol allowed further shuttle flights given that there would always be a safety margin.

The Launch Decision Process for STS 51-L

On January 15, 1986, NASA held the Flight Readiness Review for STS 51-L. Jesse Moore, the Associate Administrator for Space Flight, issued a directive on January 23rd that the Flight Readiness Review had been conducted and that 51-L was ready to fly pending closeout of any open work. No problems with any Shuttle components were identified in the directive. The L-1 Mission Management Team meeting was conducted on January 25th. No technical issues were brought up in the meeting, and all Flight Readiness Review items were closed out.

At 8:00 p.m. on Friday, January 27th, 1986, engineers and managers from Kennedy Space Center, Marshall Space Center, and Morton Thiokol, Inc. participated in the teleconference. Roger Boisjoly and Arnold Thompson, both Thiokol engineers, presented the argument that lower temperatures resulted in longer primary O-ring sealing time. Robert (Bob) Lund, the Vice President of Engineering at MTI, presented the final conclusions of the engineers. Although they agreed that factors other than temperature controlled blowby, they decided that the launch should not be held outside of the current database. Lawrence Mulloy, the Marshall Space Center Project Manager for the SRB, asked Joe Kilminster, the Vice-President of Space Booster Programs at MTI, for the formal MTI recommendation. Kilminster responded that, based on the engineering conclusions, he could not recommend launch at any O-ring temperature below 53∞F. At this point, Kilminster asked for a 5-minute off-net caucus within MTI. Approximately ten engineers and four managers participated in the caucus. Mason stated that a management decision must be made and asked Bob Lund to "take off his engineering hat and put on his management hat."

Lund, who had previously been against the launch, reversed his opinion in the subsequent discussion and agreed with the other managers to recommend a launch. The managers felt that this decision was best since much of the engineering data had been unsubstantiated and contradictory. Kilminster went on-line again and gave Marshall and Kennedy the MTI recommendation that the STS 51-L launch should occur as planned. Mueller, a NASA administrator, asked if everyone supported this decision, but no engineer from MTI responded to this question.

NASA proceeded with its plans to launch STS 51-L on January 28th, 1986.

The preceding narrative shows that the problems with the Solid Rocket Motor were well known and documented since 1977. It took national prominence when the Challenger disaster happened. The students are provided with this case study in a three-part series and asked to defend the options of "launching the shuttle" or "not launching the shuttle" either by "becoming a consultant and making a recommendation" or "deciding as a NASA manager."

(b) Adding Competency Material

In order to help students with little background in the aerospace industry analyze the case study, competency materials on the topics of field joint design and ethics were developed and included in a textbook and CD-ROM.

(c) Development of a CD-ROM

A multimedia version of the Design of Field Joint for STS 51-L Case Study was developed in order to provide a much more interactive approach to analyzing the case study. The multimedia version details the problem statement in either an audio or a textual manner. The actual case study itself is presented in a much more visual way, using a timeline that shows the different events that occurred from 1971 to 1986. By clicking on a specific year, the student can obtain further information on the events surrounding the field joint design. Clicking on the photographs on the top line yields further information about the events that happened that year. Many videos that describe different concepts such as joint rotation and blowby have also been included. Important terms and concepts are linked to their respective definitions or pictures that explain them in greater detail. If a person clicks on the menu, it shows the various options available to the students, such as checking the assignments, the tools section, etc. The decision facing the manager is also presented in both text and audio formats. A video explaining the problem statement may be viewed to further develop students' understanding of the problem. The engineer and manager's recommendations may both be accessed from the CD-ROM.

The multimedia version of the case study also provides a section entitled "Tools for Analyzing the Case Study." This section includes a textual and visual glossary of the terms used in the case study. In addition, background information on ethics and design issues are included. References to popular sites that provide more information on STS 51-L and ethics are also given. A site map provides students with the ability to go to any video or textual information without having to navigate through the menu system.

(d) Administering the Case Study in Engineering Classrooms

This case study has so far been administered to both freshman and sophomore engineering classes at Auburn University, the University of Pittsburgh, the University of Virginia, and Mercer University to a total of more than 600 students.

(e) Evaluation of the Case Study's Effectiveness

Two questionnaires (Evaluation I and Evaluation II) and an electronic journal were used to evaluate student feedback on the case study. The evaluation results from one course, ME 260 (Concepts of Engineering Design), in which this case study was used at Auburn University follow.

The means for the constructs considered in Evaluation I are reported in Table 1, and the means for the constructs from Evaluation II are given in Table 2. These means represent the students' reactions to the Design of Field Joint for STS 51-L Case Study. The scores fall on a 5-point continuum with a score of 5 representing the highest possible response.

The means are on the positive side of the continuum for all nine constructs; seven out of the nine constructs received mean ratings of over 4.0, indicating that the students had an extremely favorable reaction to the Design of Field Joint for STS 51-L Case Study.

The student comments sent to the instructors by means of an electronic journal for all the different offerings reveals in a qualitative manner the students' views on the usefulness of this case study. The case study seemed to have primarily impacted the students under three major categories: improved learning about the importance of ethics to engineers, better understanding of the engineering design process, and learning outside the objectives set for the case study. Given the positive feedback from the students, we believed it was critical that these reform-oriented instructional materials be disseminated to other engineering faculty members.

3. Selection of Focused Workshop as the Method of Dissemination

In order to disseminate these materials to other faculty, we initially used conventional methods such as presentations at

Interesting and Exciting	Important and Valuable	Instructionally Helpful	Relevant and Useful
3.8	4.2	4.0	4.3

Table 1: Means for Constructs in Evaluation I

Perceived Skill Development	Self-Reported Learning	Intrinsic Learning and Motivation	Communication Skills	Learn from Fellow Students
4.2	4.2	4.2	3.5	4.1

Table 2: Means for Constructs in Evaluation II

Workshop Goals	Focus of the Educational Materials is for the students to:
Bring theory and practice together in engineering classrooms	- Understand the non-technical forces that profoundly affect engineering decisions - Understand the technical forces that profoundly affect engineering decisions - Understand the importance of team work and communication in engineering practice
Develop higher level cognitive skills in engineering students	- Identify criteria to solve problems in unstructured situations - Analyze alternatives given multiple criteria - Make a choice and defend the choice persuasively - Be actively involved in learning situations
Provide materials that can help meet ABET 2000 Criteria	- Identify, formulate, and solve engineering problems - Understand professional and ethical responsibility - Communicate effectively - Use the techniques, skills, and modern engineering tools necessary for engineering practice

Table 3: Workshop Goals and Focus of the Educational Materials

conferences, publications in journals, and marketing the materials through a traditional publisher. Ten journal articles and 19 conference articles have been published about the results of the research on this innovative instructional methodology. When we discussed publication of the case studies with a traditional publisher, they were interested, but needed a lead time of from 2 to 3 years for publication and distribution of the materials. We believed that this would delay the dissemination effort significantly, and the new methodology would not reach faculty members in time for them to consider them for adoption as they developed curricula to meet the new ABET 2000 criteria.

We found that the traditional methods of dissemination were simply not reaching engineering educators. Our experience also shows that faculty can appreciate the case study materials only when they get involved and participate in the analysis of the instructional materials. This supposition was corroborated by faculty from the SEATEC consortium (a 2-year consortium of technical colleges) who stated that they had similar difficulties in disseminating reform-oriented materials through traditional means.

Also, we found faculty shying away from using these reform-oriented materials in their classrooms due to apprehension about how the students would react to such instructional materials. With the case study methodology used by us, the teacher's role becomes that of a facilitator and not a leader of the class. This pedagogical style is rather difficult for most teachers and requires practice before they can leave control of the class to the students. At the same time, the teachers have to be careful to ensure that the students do not steer the class into unrelated topics. The teacher has to encourage the students to perform group work. A major issue is that of grading the presentation and write-up. The teacher has to create an evaluation formula that is then shared with the students. The clearer the teacher's objectives are to the students, the better the chances are that his/her expectations will be met. It is critical to establish a mechanism to provide feedback to the students about their performance. The process of administering and evaluating a case study is very different from the conventional lecture-based instructional methodology.

Therefore, there was a strong need to design an effective way of disseminating these materials. Thus, we decided to develop focused workshops to provide hands-on training for faculty members who are willing to consider using these materials in their classrooms.

4. Details of a Focused Workshop

We obtained funding from the National Science Foundation in order to conduct a focused workshop. The objective was to provide a hands-on workshop for engineering faculty to experiment with innovative educational materials. These materials prepare students for real-world problem-solving situations and enhance their teamwork, interpersonal, and interdisciplinary skills. Table 3 lists the workshop goals and the focus of the educational materials.

The workshop sessions were spread over a 3-day period and included numerous opportunities for the participants to have hands-on experience with the multimedia case studies. The participants in the workshops included faculty members from both 4-year and 2-year colleges and represented a range of engineering disciplines. They were provided with individual computers and a CD-ROM of the case study and worked in teams. They had about two and a half hours to read the textbook, work on the CD-ROM, and discuss their findings with their team members. In some of the workshops, the faculty members made presentations, and, in others, student teams made the presentations assisted by faculty members. In one of the workshops, Mr. Roger Boisjoly, a former MTI engineer who participated in the teleconference relat-

Participant Profile	Workshop Held During			
	May 11-13, 2000	Feb. 22-24, 2001	Sept. 27-29, 2001	March 21-23, 2002
Number of participants:				
- Faculty	30	22	30	40
- High school teachers	2	0	2	0
- Students	17	10	17	14
Institutions Represented	12[1, 9]	16[2]	24[3]	28[4, 10]
Participating minority-serving institutions	3[5]	1[6]	4[7]	3[8]
Participation of under-represented faculty groups				
- Women	2	7	2	6
- African-American	3	0	3	2
- Hispanic American	0	1	0	1

Table 4: Profile of the Workshop Participants

[1] University of Windsor, Auburn University, Texas Tech, University of Virginia, University of Florida, University of Iowa, Middle Tennessee State University, Vanderbilt University, Georgia Institute of Technology, Widener University, United States Navy, Illinois Institute of Technology.

[2] Mercer University, Clarkson University, Virginia Tech., UAB School of Engineering, Mississippi State University, University of Denver, Tennessee Tech., Georgia Tech., University of Florida, University of Houston, Rensselaer Polytechnic Institute, Youngstown State University, Michigan State University, Sir Sanford Fleming College, Nashville State Technical Institute, and Alabama A&M University

[3] Alabama Southern Community College, Auburn University, Del Mar College, Duke University, Gaston College, Illinois Institute of Technology, Indiana University, Purdue University, Inst. Tech. Y de Estudios Superiores de Monterrey, Jones Country Jr. College, Learning Unlimited, Nashville State Tech, North Dakota State University, Oklahoma State University, Purdue University, Southern Illinois University, St Louis University, Tennessee Technological University, Texas Tech University, University of Detroit Mercy, University of Central Florida, University of Florida, University of Louisville, University of Virginia, Vanderbilt University

[4] Aiken Technical College, Alabama A & M University, Auburn University, Cleveland State Community College, Learning Unlimited, Mercer University, Michigan Technological University, Nashville State Technical Institute, National Academy of Engineering, National Science Foundation, National University of Health Sciences, North Carolina State University, North Dakota State University, Northern Illinois University, Pennsylvania College of Technology, University of Alabama at Birmingham, University of Arizona, University of Arkansas, University of British Columbia, University of Central Florida, University of Louisville, University of Maryland, University of Nevada, Las Vegas, University of Santiago of Chile, University of Texas at Tyler, University of Toledo, Vanderbilt University, Wilkes University

[5] Alabama A&M University, North Carolina A&T University, Tuskegee University.

[6] Alabama A&M University

[7] Alabama Southern Community College, Inst. Tech. Y de Estudios Superiores de Monterrey, North Dakota State University, University of Detroit Mercy

[8] Alabama A & M University, Cleveland State Community College, University of Santiago of Chile

[9] Dr. Eric Sheppard, Program Director, National Science Foundation.

[10] Dr. Russell Pimmel, Program Director, National Science Foundation.

ing to the launch of the Challenger space shuttle, was invited to critique and work with the faculty members and student teams. The presentations were well received, and the faculty members and students discussed the alternatives and the technical issues extremely well. In addition, we videotaped the faculty and student presentations during the workshop.

5. Profile of the Workshops

During 2000-2002, four workshops were held that were attended by a total of 122 faculty members, 4 high school teachers, and 58 students. Of these, 27 faculty members represented under-represented faculty groups. The faculty members came from 4-year and 2-year institutions and high schools. Fifteen distinguished speakers addressed the workshop participants and discussed issues related to engineering education and the ABET 2000 criteria. Table 4 provides a profile of the faculty members who attended the workshops. The details of the institutions they represented are shown as footnotes.

6. Evaluation of the Focused Workshops

Two faculty members from the College of Education at Auburn University evaluated the effectiveness of the workshops and the results are presented in this section. During the first workshop, at the completion of each case study engineering educators completed two evaluation surveys. Since the results were positive and the completion of the surveys took a significant time, these two surveys were not administered in the subsequent workshops. This section provides the results of the evaluation of the individual case studies in the first workshop. In addition, at the end of the three sessions, the participants were given an additional evaluation form. This form asked participants to rate the workshop's effectiveness in providing hands-on experiences with case studies, demonstrating educational and problem-solving strategies, highlighting the importance of non-technical issues, providing opportunities to learn from colleagues, showing examples of engineering students' work, and demonstrating the importance of information technologies. These results are also provided in this section, along with the participants' comments about the effectiveness of the workshops and suggestions for future workshops.

Evaluation of the Case Studies Used in the Workshops

During the first workshop, at the completion of each case study engineering educators completed two evaluation surveys. Of most relevance to this particular audience was Evaluation I, which consisted of 24 bipolar descriptors, with items on the evaluation form representing concepts such as clarity, relevance, importance, or meaningfulness on a 5-point continuum. Evaluation II asked the respondents to indicate how strongly they agreed with 16 evaluatory statements on a 5-point Likert scale, ending with three open-ended questions which asked workshop participants to provide written responses regarding the strengths and weaknesses of each specific case study. The items from Evaluation I collapsed into four different scales or constructs. Sample responses from the open-ended prompts were also provided.

Because a score of 5 would represent the most positive reaction to any descriptor in Evaluation I, it can be assumed that any score above a 3 indicates a favorable response to that particular construct for each case study. Table 5 shows the means for responses on the four separate constructs for each case study.

All four constructs for each case study received favorable ratings from the engineering educators attending the conference. Specifically, from observing the means, it appears that the engineering educators found each case study to be highly relevant and useful. It also appears that the Design of the Field Joint for STS 51-L Case Study received the most favorable ratings of the three case studies presented. Additional comments on the evaluations also supported the favorable reactions to each of the three case studies. Sample comments regarding strengths of the various case studies include the following: "linking theory to real world problems," "developing problem solving skills," "ability to apply real world problems to classroom learning," "details well-provided," and "good coupling of subjective (human) decision making and use of engineering analyses." Both comments and ratings provided by the engineering educators were positive for each specific case study.

Evaluation to Measure Whether Workshop Objectives Were Met

The evaluation of these workshops was conducted from two perspectives using the responses from the workshop participants. First, the workshop participants responded to a five-item four-choice Likert-type rating scale that measured the extent of their agreement/disagreement with statements regarding the workshop. The four-choice Likert scale response options ranged from strongly agree to strongly disagree. The same participants also responded to three open-ended questions.

This section presents the frequencies of responses for the five four-option Likert-scale items. The first item was "The workshop provided hands-on experiences using innovative educational materials." The responses are reflected in Table 6.

As 98% of the respondents either agreed (22.6%) or strongly agreed (75.5%) that the workshop provided hands-on experiences using innovative educational materials, this objective was met.

The results from the responses to the second item, "The workshop provided educational strategies which prepare students

	Interesting and Exciting	Important and Valuable	Instructionally Helpful	Relevant and Useful
Crist (N = 16)	3.72	3.90	3.82	4.12
Design of the Field Joint for STS 51-L (N = 12)	4.11	4.13	4.13	4.25
Della (N = 15)	3.91	4.27	3.95	4.30

Table 5: Means per Construct in Evaluation I

Response Options	Frequencies				Percentage	Cumulative Percentage
	Workshop II (n=17)	Workshop III (n=18)	Workshop IV (n=18)	Three workshops (n=53)		
Strongly agree	15	17	8	40	75.5	75.5
Agree	2	1	9	12	22.6	98.1
Disagree	0	0	1	1	1.9	100.0
Strongly disagree	0	0	0	0	0	
Total	17	18	18	53	100	

Table 6: Frequencies and Percentages Choosing the Various Response Options to Item 1: The Workshop Provided Hands-On Experiences Using Innovative Educational Materials

Response Options	Frequencies				Percentage	Cumulative Percentage
	Workshop II (n=17)	Workshop III (n=18)	Workshop IV (n=18)	Three workshops (n=53)		
Strongly agree	14	17	9	40	75.5	75.5
Agree	3	1	9	13	24.5	100.0
Disagree	0	0	0	0	0	
Strongly disagree	0	0	0	0	0	
Total	17	18	18	53	100	

Table 7: Frequencies and Percentages Choosing the Various Response Options to Item 2: The Workshop Provided Educational Strategies Which Prepare Students to Solve Real-World Problems

Response Options	Frequencies				Percentage	Cumulative Percentage
	Workshop II (n=17)	Workshop III (n=18)	Workshop IV (n=18)	Three workshops (n=53)		
Strongly agree	10	15	10	35	66.0	66.0
Agree	7	3	7	17	32.0	98.0
Disagree	0	0	1	1	2.0	100.0
Strongly disagree	0	0	0	0	0	
Total	17	18	18	53	100	

Table 8: Frequencies and Percentages Choosing the Various Response Options to Item 3: The Workshop Demonstrated the Importance of Non-Technical Issues When Making Decisions in the Engineering Field

to solve real world problems," are given in Table 7.

One hundred percent of the respondents either agreed (24.5%) or strongly agreed (75.5%) that the workshop provided strategies that would prepare students to solve real-world problems, thus indicating that this objective was met.

The results from the responses to the third item, "The workshop demonstrated the importance of non-technical issues when making decisions in the engineering field," are shown in Table 8.

The responses to Item 3 were not quite as positive as the responses to Items 1 and 2, but 98% of the respondents still either agreed (32%) or strongly agreed (66%) that the workshop demonstrated the importance of non-technical issues when making decisions in the engineering field, thereby indicating that this objective was met.

The results from the responses to the fourth item, "The workshop provided opportunities to learn from colleagues," are given in Table 9.

Again, 100% of the respondents either agreed (17%) or strongly agreed (83%) that the workshop provided opportunities to learn from colleagues, indicating that this objective was met.

The results from the responses to the fifth item, "The workshop demonstrated the use of information technologies in engineering education," are given in Table 10.

Once more, 100% of the respondents either agreed (31.4%) or strongly agreed (68.6%) that the workshop demonstrated the use of information technologies in engineering education, indicating that this objective was met.

Themes that Emerged from the Comments of the Participants

To assess the qualitative aspect of the workshop, the participants were asked to describe their perceptions of the strengths and weaknesses of the workshop and suggest any changes or improvements that could be made. The qualitative responses were congruent with the quantitative responses to the rating scale given by the

Response Options	Frequencies				Percentage	Cumulative Percentage
	Workshop II (n=17)	Workshop III (n=18)	Workshop IV (n=18)	Three workshops (n=53)		
Strongly agree	13	14	17	44	83.0	83.0
Agree	4	4	1	9	17.0	100.0
Disagree	0	0	0	0	0	
Strongly disagree	0	0	0	0	0	
Total	17	18	18	53	100	

Table 9: Frequencies and Percentages Choosing the Various Response Options to Item 4: The Workshop Provided Opportunities to Learn From Colleagues

Response Options	Frequencies			Percentage	Cumulative Percentage
	Workshop II (n=17)	Workshop III (n=18)	Two workshops (n=35)		
Strongly agree	13	11	24	68.6	68.6
Agree	4	7	11	31.4	100.0
Disagree	0	0	0	0	
Strongly disagree	0	0	0	0	
Total	17	18	35	100	

Table 10: Frequencies and Percentages Choosing the Various Response Options to Item 5: The Workshop Demonstrated the Use of Information Technologies in Engineering Education

Participants working on a team project using mouse traps.

participants of the workshop and were overwhelmingly positive about the workshop.

For example, among the 53 participants who participated in the evaluation of the three workshop sessions, there were 87 statements praising the various strengths of the workshop format, 27 comments concerning weaknesses, and 40 statements suggesting changes. That over half of the participants identified no weaknesses was another strong positive commentary on the quality of the workshops. Although the overall tenor of the evaluation was extremely positive, there were 40 suggestions for changes or improvements in the workshops.

With regard to the perceived weaknesses of the workshops, the dominant theme revealed by the comments was that a majority of the participants noted no weaknesses. The written comments that were returned and the evaluators' observations of the workshops yielded the following observations and suggestions: the participants felt that the auditorium seating did not facilitate interaction, the amount of information to be assimilated in the time given was excessive, more diversity in the participants was desirable, the case studies were too closely tied to mechanical engineering projects, and there was too much emphasis on the demonstration of what had already been developed rather than a workshop on how to actually implement the case method in the classroom. A few of the participants (n=3) mentioned a software incompatibility problem (CD) which was quickly corrected. Another participant felt the workshop would benefit from including more MBA faculty, while another commented that the workshop "was specifically concerned with mechanical only and business type problem solving…needs to be more general…other engineering options should be included." Another participant made the following comment, "Did not like the case study assignment for the SRB where we played the role of engineering/management and then had the students present. Would rather see workshop participants present. Exercise goal was unclear." Other comments included: "I'm not sure what the overall goal of the workshop was, and how the activities fit in" and "Get raw materials and ask participants to develop case study."

Many participants had suggestions for changes. Based upon the weaknesses already noted and the suggested changes, these changes would enhance what were generally perceived by the participants to be very high-quality workshops. Probably the dominant suggestion for improvement is that there should be more specific instructional guidance provided, along with examples of how to teach using the case method. The participants thought that substantially more time should be devoted to demonstrations of how to actually teach using case studies, with less time devoted to demonstrations of the multimedia materials. Lesson plans, instructional strategies, and videotapes of actual instructional activities could be more widely used. More examples of how to evaluate individual students would also be helpful. Others suggested adding other areas of engineering, such as safety, ergonomics. Several suggestions were specific to the topic of case studies, including: "Request that invitees bring three (3) case ideas with them to the workshop. Have an exercise to expand some of these selected possible case studies during the workshop", "Add a section on some details about how the case studies were put together (e.g., what kind of multi-media software used, how much 'human-hours' were needed, what kind of infrastructure you have at your disposal, etc.)." Some other suggestions concerned the need for more discussions about the ABET criteria and the possible allocation of time during working hours to visit the labs. Other suggestions included: "If possible, send workshop agenda to the participants before they have to make airline arrangements - if possible."; "Too intense; maybe little breaks in between sessions will be helpful."; "Instead of 3 days; 2 days workshop will be more appropriate."; and "Find some way to cover things in two days versus three." Overall, the participants thought that more time would have helped them to properly understand the case method and its instructional use.

From the 87 strengths of the workshop, eight major themes were identified; and these are presented in descending order of dominance. For the strengths of the workshop, the two dominant themes identified were team building or teamwork and hands-on application of the case methodology. For the team building or teamwork theme, comments like "team building," "idea sharing," "team work style," and "colleague participation" were given. For the hands-on application theme, comments were "hands on experiences," "hands on activities," applications of case methodology to business and engineering students," "inspirational," "outstanding workshop that continues to make giant strides in developing SMET education of the future," "accomplished something, not merely learned something about active learning methods," and "good opportunity for reflection and application."

The next most obvious strength of the workshop centered around the activity and enthusiasm of the workshop organizers, presenters, and participants. Examples of comments were "maintained participant enthusiasm," "enthusiasm of workshop organizers," "excellent time management," "strong organization," "keeping participants active and involved," "speakers were incredible," and "participants kept moving."

The next strength noted focused on the organization of the workshop. Examples of comments were "well organized," "organization of the workshop," "thoroughness," "diversity of pieces," "excellent materials," and "well orchestrated." One participant commented, "Well thought out plan for the workshop, leading participants from introduction to the case studies, through an adaptation exercise, and ultimately to an implementation exercise. Workshop participants are cleverly led to buy and implement the materials in the curriculum."

The next three strengths were represented equally. These were evaluation, use of multimedia, and speakers/presentations. For the evaluation, comments included the "idea of E-journal to evaluate and enhance meta-cognitive skills," "studies/ data that case method increases student's quantitative problem solving," and "effective demonstration of the success and efficacy of the case study approach in undergraduate instruction." For the use of multimedia, the following types of comments were made: "providing CDs of case studies," "use of multimedia in the aid of learning," and "multimedia use." The third of the similarly ranked themes was the quality of the presentations/ speakers. Examples of this theme were "good choice of speakers," "guest speakers were engaging," "incredible speakers," "excellent presentations," awed and impressed by Dr. Wulf's vision," and "very informative session with Roger Boisjoly."

The last theme was that the participants had learned new information/skills and was characterized by comments like "learned new things," "learned innovative methods that I can use in my classroom," "a non-mainstream method of teaching can be used to cover technical concepts of engineering principles effectively," "pioneering teaching technique in the field of engineering," "excellent introduction to case studies and their role and importance to engineering education," "informative," and "workshop was inspirational to a junior faculty like me who is struggling with the problems of conventional engineering education and who has little experience to fall back upon."

Summary of Evaluation

In summary, the comments about the workshop from participants were generally favorable. Many enjoyed the food, facilities, and energy and excitement of the workshop members, and felt that the workshop was productive in disseminating innovative instructional materials that bring real-world issues into classrooms. As one participant suggested, "Please keep up the good work!! It was worth the sacrifice of being away from my students. I have learned something invaluable & will put it to good use." It appears from the reactions to all three case studies, as well as the overall reactions to the workshops, that engineering educators found the information to be beneficial to them in their role as teachers and facilitators of knowledge. A final suggestion for change summarizes the overall positive response of the workshop participants: "Take this show on the road."

7. Adoption of Instructional Materials in Different Universities

Due to their participation in these workshops, many faculty members have become positively predisposed toward using the materials developed by LITEE in their classrooms. These materials have been used in the following institutions in addition to Auburn University:

(a) Alabama A&M University, Electrical Technology Program: adopted the Della case study to teach an instrumentation course. It was very well received by the students. According to their professor, this methodology was the most effective way he had found to motivate his students to improve their higher-level cognitive skills (Raju et al., 2000).

(b) University of Virginia, Introduction to Engineering Course: used the Design of the Field Joint for the STS 51-L Case Study. The instructor found that the case study method really helped students to experience a realistic and complex scenario. He said that the Challenger case study showcases the enormous influence that human and bureaucratic relationships can exert on the decision-making process. He liked the multimedia presentation of the case and the background provided on the CD- ROM. He felt that it was both an excellent learning and teaching tool, and it added to the enjoyment of learning.


Participants making a case study presentation.

(c) Illinois Institute of Technology, Introduction to Engineering Course: used both the Crist and Della case studies. The instructor stated that the case studies were very helpful to the students in learning about real-world decision-making issues.

(d) Mercer University: Introduction to Engineering Course: used the Design of the Field Joint for the STS 51-L Case Study. The students were pleased to be analyzing a real-world problem that involved the integration of engineering design and ethics.

(e) Indiana University Purdue University: used the Design of the Field Joint for the STS 51-L case study in a design project course. The instructor stated that the students benefited greatly.

(f) Embry-Riddle Aeronautical University: used the Crist case study. The instructor stated that the students enjoyed analyzing the case study and using the Expert System.

(g) Louisiana State University: used the Crist, Chick-fil-A, and Aucnet case studies with undergraduate and graduate business students. The feedback is excellent and has led to several publications.

At the same time, some of the faculty members have expressed difficulties in convincing their colleagues of the need to use such reform-oriented materials in the classrooms. A participant of our workshop was very enthusiastic about introducing a case study format in his/her institution but had difficulty in implementing it. The participant's experience is paraphrased herein: "The team was ready and all the players were debriefed and given the case months ahead of time. Each class taught their portions of the case, and the Today's Tech Professor was to pull it all together introducing the case and showing how the material in the other courses link to it. Unfortunately, even though I met weekly with this professor and gave him complete assignments to hand out and step-by-step instructions on how to introduce the case in his lecture, he decided one hour before presenting it to simply not do the case at all. Therefore, 6 months of curriculum planning went down the tubes. His rationale for this decision was completely self-serving due to the workload he thought it meant for him. Apparently, he gave us the impression that he had reviewed the case although he had never looked through the material, waited till the last minute to review the case, and panicked. If I ever do this again, I would sit all faculty involved down in a room together while they were going through the entire CD and have them do their presentation (just as you did). Due to time, I sent them off with the case study on their honor to go over it, after I did a 30-40 minute introduction with the CD (just as you did in the presentation). Faculty stated that they didn't have time to get to the presentation mode and in hindsight, this was a great error."

8. Summary and Conclusions

This article shows that the instructional methodology that we developed using case studies accomplished the objectives of integrating engineering theory, design, and practice. It also helps students develop their teamwork skills and higher-level cognitive skills. Our experience shows that focused workshops where faculty have opportunities to obtain hands-on experience with the instructional materials are a very effective way of disseminating reform-oriented instructional materials. Even with that experience, many faculty members have difficulty convincing their colleagues to use such materials in the classrooms. The NSF report (Tushnet et al., 2000) states that marketing of reform-oriented K-12 instructional materials was most effective when it involved professional development in the form of in-person seminars and hands-on workshops. Our experience corroborates this finding for 2-year and 4-year colleges and shows a strong need for federal funding support for such focused workshops in disseminating innovative instructional materials.

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Over the past 15 years, his evaluation efforts have been in engineering education with extensive involvement in pre-engineering where an emphasis is on retention. He assisted in the development of the College Freshman Survey which is administered to all entering freshman students. He has established databases with these students who have been followed from the entering freshman level through graduation. For some of his engineering evaluation projects, he has data going back to the high school level. He has co-written an evaluation manual which provides a data-based justification for advising potential pre-engineering students before they actually enter Auburn University.

Dr. Halpin has also been actively involved with Drs. Raju and Sankar, assisting them with the evaluation of their innovative engineering education projects over the past 5 years. His primary contributions to the Raju/Sankar team have been in data management and analysis along with the establishment of psychometrically defensible evaluation tools.

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Working with Drs. Raju and Sankar, she, along with Gerald Halpin, has primary responsibility for the evaluation activities associated with LITEE (Laboratory for Innovative Technology and Engineering Education). Together, they all have received external funding for the initial and continuing support of this innovative way of improving undergraduate education through multimedia case studies based on real-world problems. Among her 250 research publications and presentations are papers focusing on evaluations of LITEE endeavors.

Dr. Halpin is a member of the International Association of Applied Psychologists, International Council of Psychologists, American Evaluation Association, American Educational Research Association, National Council on Measurement in Education, and American Society for Engineering Education as well as other national and regional research and professional organizations in which she has held offices and served on various committees and boards.