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Dissemination of Innovations from Educational Research Projects: Experience with Focused Workshops

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Abstract

During 1996, we formed the Laboratory for Innovative Technology and Engineering Education (LITEE). 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 partnering with industries to bring real-world engineering problems into classrooms. The case studies illustrate how a problem in an industry is analyzed and solved. The format chosen by us enabled the students to experience the problem as it happened and develop and compare their solutions with what happened in the industry.

These innovative educational materials received several awards including the Thomas C. Evans, Jr., Instructional Unit Award of ASEE Southeastern Section, Premier Award for Excellence in Engineering Education Courseware of NEEDS, and ASME Curriculum Innovation Award. In order to disseminate these materials to other faculty, we tried the normal ways such as presentation in conferences, publication in journals, and marketing of these materials through a traditional publisher. We found that these methods were not that effective in reaching the 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 shy away from reform-oriented instructional materials because they are new and controversial and that a major barrier faced by the developers was the perceived absence of a market for reform-oriented materials.

We then developed a focused workshop during May 2000 with sponsorship from the National Science Foundation wherein faculty were provided an opportunity to get hands-on experience with the use of our multimedia case studies. This workshop was very successful, and the evaluation results encouraged us to offer two more workshops during 2001. The feedback and evaluation of 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 evaluation and feedback received from the participants. We conclude that "focused workshops" are an excellent means of disseminating innovative educational materials developed by faculty.

Introduction

A paradigm shift is taking place in engineering, and technology education, driven by the National Science Foundation (NSF), Accreditation Board for Engineering and Technology Education (ABET), changing expectations of employers, changing state-of-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; start with the student's experience, but have high expectations within a supportive climate; and build inquiry, a sense of wonder, and the excitement of discovery, plus communication and teamwork, critical thinking, and life-long learning skills into learning experiences (Shaping the Future, 1996).

How has the education establishment reacted to the need for educating engineering students using the above approach? The National Science Board states 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 and Proctor, 2000). These observations show that the education establishment is not doing an adequate job of engineering students. This in our opinion is because the 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). 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 partnering with industries to bring real-world engineering problems into classrooms. The case studies illustrate how a problem in an industry is analyzed and solved. The format chosen by us enabled the students to experience the problem and develop and compare their solutions with what happened in the industry.

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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 evaluation results 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 the selection of the focused workshop as one of the effective methodologies. Section 4 describes the details about a focused workshop and how both 4-year and 2-year engineering educators were provided a hands-on training on the innovative materials. Section 5 provides the results of the evaluation of two focused workshops. Section 6 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 industry partners, (b) adding competency material on engineering and business topics that students may use as 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

We 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

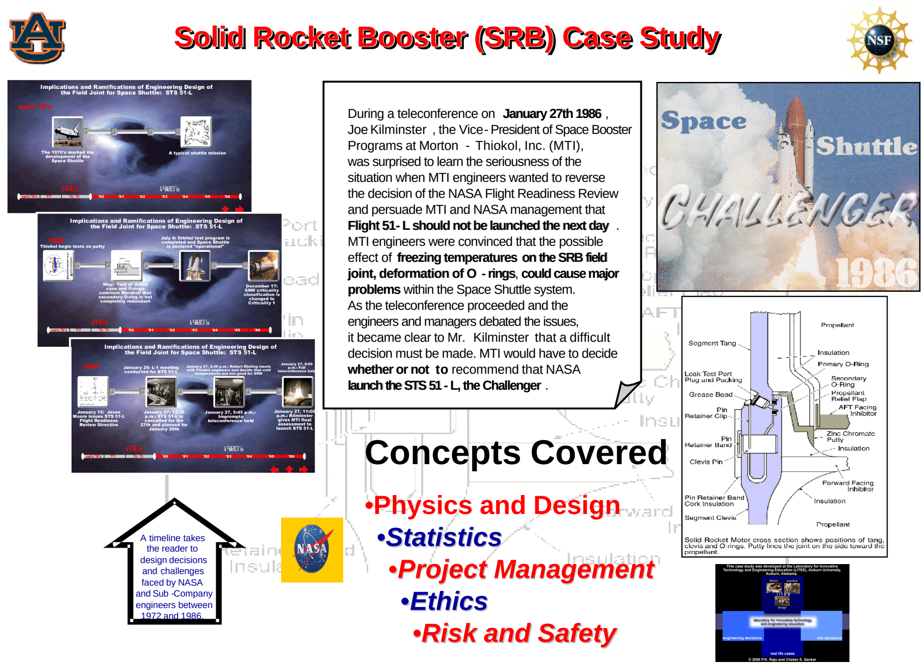

Figure 1

To provide an example, we discuss herein the details of the Design of Field Joint for STS 51-L Case Study. 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 below 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 as 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. 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 tan and clevis
3. Oversized O-rings
4. Redesign tang and reduce tolerance on clevis
5. Combination of redesign (Option 4) and use of shims

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 since there would always be this 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 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 this case study in a three-part series and asked to defend the options of "launching the shuttle," "not launching the shuttle," "becoming a consultant and making a recommendation," and "deciding as NASA managers."

(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 the 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 an audio or a textual manner. The actual case study itself is presented in a much more visual nature using a timeline that shows the different events that occurred from 1971 to 1986. By clicking on a specific year, the student could obtain further information on the events surrounding the field joint design. Clicking on the photographs on the top line could yield further information about the events that happened in that year. Many videos that describe different concepts such as joint rotation and blowby have been included. Important terms and concepts are linked to their respective definitions or pictures that further 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 a text and audio format. A video explaining the problem statement may be viewed to develop further 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 an 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 been administered in both freshman and sophomore engineering classrooms at Auburn University, University of Pittsburgh, University of Virginia, and Mercer University to more than 600 students.

(e) Evaluation of the Effectiveness

Two questionnaires 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 are discussed herein.

The means for the constructs considered in Evaluation I are reported in Table 2, and the means for the constructs from Evaluation II are given in Table 3. These means represent the students' reactions to the Design of Field Joint for STS 51-L Case Study.

Table 2: Means for Constructs in Evaluation I

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

Table 3: Means for Constructs in Evaluation II

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

Given that 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. In fact, seven out of the nine constructs received mean ratings over a 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 student comments on the usefulness of this case study. The case study seemed to have impacted the students under three major categories:

improved learning about importance of ethics to engineers, better understanding of 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 tried the normal ways such as presentations in conferences, publications in journals, and marketing of these 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 wanted about 2 to 3 years for publication and distribution of the materials. We believed that this will delay the dissemination effort significantly, and the new methodology will not reach the faculty members in time for them to adapt in their curriculum that is being modified to meet the new ABET 2000 criteria.

We found that the traditional methods of dissemination were not that effective in reaching the 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 with apprehensions 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, but 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 needs to be 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. So, we decided to develop “focused workshops” that provide hands-on training for faculty members who are willing to use these materials in their classrooms.

4. Details of a Focused Workshop

We obtained funding from the National Science Foundation for conducting a focused workshop. The objective is 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 teaming, interpersonal, and interdisciplinary skills. Table 4 lists the workshop goals and focus of the educational materials.

Table 4: Workshop Goals and Focus of the Educational Materials

Workshop Goals	**Focus of the Educational Materials is for the students to:**
Bring theory and practice together in engineering classrooms	- Understand non-technical forces that profoundly affect engineering decisions - Understand technical forces that profoundly affect engineering decisions. - Understand 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.

The workshops were spread over a 3-day period and included numerous opportunities for the participants to have hands-on experience with the multimedia case studies. Appendix A provides the agenda of one workshop. The participants in the workshops included faculty members from both 4-year and 2-year colleges and represented different engineering disciplines. They were provided 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 the faculty members. In one of the workshops, we had invited Mr. Roger Boisjoly, a former MTI engineer who participated in the teleconference relating to the launch of the Challenger space shuttle, to critique and work with the faculty members and student teams. The presentations went very well, 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.
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5. Evaluation of the Focused Workshop

Two faculty members from the College of Education, Auburn University, evaluated the effectiveness of the workshop. So far, three such workshops have been organized by LITEE at Auburn University. The evaluation results of two of these workshops are presented in this section.

Profile of the First Workshop Held During May 11-13, 2000

Number of Faculty Participants: 30
Number of Student Participants: 17
High School Teachers: 2

Institutions Represented: 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.

Participating Minority-Serving Institutions: Alabama A&M University, North Carolina A&T University, Tuskegee University.

Participation of Under-Represented Groups: Two women, three African-American faculty members

Keynote Speakers:
Dr Eric Sheppard, Program Director, National Science Foundation, Arlington, VA, " Science, Math, Engineering, and Technology Education (SMET): Creative Development, Adaptation, Assessment and Dissemination - Funding Opportunities"

Dr John Prados, Vice President (Emeritus) and University Professor and Editor in Chief ASEE Journal of Engineering Education, The University of Tennessee, Knoxville, TN, "Educating Engineers for the 21st Century: New Challenges, New opportunities, New Partnerships"

M. Dayne Aldridge, Dean and Professor, Mercer University (Past Chair ABET Engineering Accreditation Commission), "EC2000: Finding a Balance Between Engineering Theory and Practice "

Evaluation Results of the First Workshop

In order to share the case study method of instruction with other engineering educators, the case study method of instruction, with examples of three distinct case studies, was presented to engineering educators at a conference in Auburn, Alabama. 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 their extent of agreement with 16 evaluatory statements on a 5-point Likert scale and ended with three open-ended questions which asked workshop participants to provide written responses regarding 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.

Table 5: Means per Construct in Evaluation I

	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

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 that day. 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 regarding each specific case study.

An additional evaluation form was given to the workshop participants. This form asked participants to rate the workshop's effectiveness in providing hands-on experiences with case studies, providing educational and problem-solving strategies, demonstrating the importance of non-technical issues, providing opportunities to learn from colleagues, providing examples of engineering students' work, and demonstrating the importance of information technologies. These six items received only positive ratings (strongly agree or agree) from the workshop participants. The first item, asking if the workshop effectively provided hand-on experiences to use innovative educational materials, received strongly agree ratings from over 90% of the participants. In overall comments regarding the workshop, participants described the workshop as a "mind opening experience," "well organized," and exposure to "dynamic faculty who are interested in making a difference by adopting new materials."

Thus, it appears from the reactions to all three case studies as well as the overall reactions to the workshop that engineering educators found the information to be beneficial to them in their role as teacher and facilitator of knowledge. A final suggestion for change summarizes the overall positive response of the workshop participants: "Take this show on the road."

Profile of the Second Workshop Held During Feb. 22-24, 2001

Number of Faculty Participants: 22
Number of Student Participants: 10

Institutions Represented: 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, Renessaelaer Polytechnic Institute, Youngstown State University, Michigan State University, Sir Sanford Fleming College, Nashville State Technical Institute, and Alabama A&M University

Participating Minority-Serving Institutions: Alabama A&M University

Participation of Under-Represented Groups: Seven women, one Hispanic American

Keynote Speakers:

Ms. Sydney Rogers, Vice President, Nashville State Technical College, "Collaboration Between 2-Year and 4-Year Colleges: SEATEC and LITEE"

Mr. Roger Boisjoly, Ethics Lecturer, "The Space Shuttle Challenger Disaster: Ethics, Integrity, and Professionalism in Engineering Organizations"

Dr. Karl Smith, Morse-Alumni Distinguished Professor, University of Minnesota, "Effective Team Work Practices for Inquiry-Based Learning"

Evaluation Results of the Second Workshop

The evaluation of this workshop was conducted from two perspectives using the responses from 17 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.

Presented in this report are frequencies of responses to the five four-option Likert-scale items. The first item was "The workshop provided hands-on experiences using innovative educational materials." Responses are reflected in Table 6.

Table 6: Frequencies and Percentages Choosing the Various Response Options to Item 1:

The Workshop Provided Hands-On Experiences Using Innovative Educational Materials.

Responses options	Frequency	Percent	Cumulative percent
Agree	2	11.8	11.8
Strongly Agree	15	88.2	100.0
Total	17	100.0	

That 100% of the respondents either agreed (11.8%) or strongly agreed (88.2%) that the workshop provided hands-on experiences using innovative educational materials indicates that this objective was met.

The results from the responses to the second item, "The workshop provided educational strategies which prepare students to solve real world problems," are included in Table 7.

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.

Responses options	Frequency	Percent	Cumulative percent
Agree	3	17.6	17.6
Strongly Agree	14	82.4	100.0
Total	17	100.0	

That 100% of the respondents either agreed (17.6%) or strongly agreed (82.4%) that the workshop provided strategies that prepare students to solve real-world problems indicated 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 included in Table 8.

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.

Responses options	Frequency	Percent	Cumulative percent
Agree	7	41.2	41.2
Strongly Agree	10	58.8	100.0
Total	17	100.0	

The responses to Item 3 were not as positive as were the responses to Items 1 and 2. However, that 100% of the respondents still either agreed (41.2%) or strongly agreed (58.8%) that the workshop demonstrated the importance of non-technical issues when making decisions in the engineering field indicates that this objective was met.

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

Table 9: Frequencies and Percentages Choosing the Various Response Options to Item 4:

The Workshop Provided Opportunities to Learn From Colleagues.

Responses options	Frequency	Percent	Cumulative percent
Agree	4	23.5	23.5
Strongly Agree	13	76.5	100.0
Total	17	100.0	

That 100% of the respondents either agreed (23.5%) or strongly agreed (76.5%) that the workshop provided opportunities to learn from colleagues indicates 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 included in Table 10.

Table 10: Frequencies and Percentages Choosing the Various Response Options to Item 5:

The Workshop Demonstrated the Use of Information Technologies in Engineering Education.

Responses options	Frequency	Percent	Cumulative percent
Agree	4	23.5	23.5
Strongly Agree	13	76.5	100.0
Total	17	100.0	

That 100% of the respondents either agreed (23.5%) or strongly agreed (76.5%) that the workshop demonstrated the use of information technologies in engineering education indicate that this objective was met.

For the qualitative aspect of the workshop the participants were asked to write their perceptions of the strengths and weaknesses of the workshop and any suggested changes. The qualitative responses were congruent with the quantitative responses to the rating scale given by the participants of the workshop. The participants were overwhelmingly positive about the workshop. For example, among the 17 participants who participated in the evaluation of the workshop, there were 49 statements of the various strengths of the workshop, 9 comments concerning weaknesses of the workshop, and 18 statements concerning the suggested changes to the workshop. That over half of the participants (9 out of 17) noted no weaknesses of the workshop was another strong positive commentary on the quality of the workshop. Although the overall tenor of the evaluation was extremely positive, there were 18 suggestions for change or improvement in the workshop.

For the weaknesses of the workshop, the dominant theme as can be seen from the participants actual comments was that 9 of the 17 participants noted no weaknesses in the workshop. From these written comments and the evaluators observations of the workshop, the participants felt that the auditorium seating did not facilitate interaction, the amount of information in the time given was too much, and there was too much emphasis on demonstration of what had been developed and not a workshop on how to actually implement the case method in the classroom.

Fourteen of the 17 participants had suggestions for change. Based upon the stated weaknesses and the suggested changes, these changes would enhance what was perceived by the participants to be a very high-quality workshop. Probably the dominant suggestion for improvement is that there be more specific instructional methods and examples on how to teach using the case method. The participants perceived that substantially more time should be devoted to demonstrations of actually how to teach using case studies and less time devoted to demonstration of the multimedia materials. Actual lesson plans, instructional strategies, and videotapes of actual instructional activities could be more widely used. Overall, more time is needed to understand adequately the case method and its instructional use.

From the 49 strengths of the workshop, eight major themes were identified; and they are presented in descending order of dominance. For the strengths of the workshop, the two dominant themes given 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,” 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,” and “ good opportunity for reflection and application.”

The next most dominant 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,” and “participants kept moving.”

The next strength focused on the organization of the workshop. Examples of comments were “well organized,” “organization of the workshop,” and “well orchestrated.”

The next three strengths were represented equally. They 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 CD’s of case studies” and “multimedia use.” The next of the similarly dominant themes was the quality of the presentations/speakers.

Examples of this theme were "good choice of speakers," "guest speakers were engaging," and "very informative session with Roger Boisjoly."

The last theme was that the participants had learned new information/skills which was characterized by comments like "learned new things" and "informative."

6. 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:

(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 the professor, this methodology was the best in motivating 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 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 its background provided on CD- ROM. He felt that it was both an excellent learning and teaching tool, and it added to the enjoyment of learning.

(c) Illinois Institute of Technology, Introduction to Engineering Course. Used Crist and Della case study. 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 analyze a real-world problem that involved integration of engineering design and ethics.

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 in implementing a case study 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 handout 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."

7. 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 teaming skills and higher-level cognitive skills. Our experience shows that focused workshops where faculty have opportunities to get 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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Appendix A
Bringing Theory and Practice Together in Engineering Classrooms
Feb. 22-24, 2001
Auburn University Hotel and Conference Center, Auburn, AL 36849
Program
Sponsored by: Laboratory for Innovative Technology and Engineering Education (LITEE),
Auburn University and National Science Foundation

Feb. 22, 2001

07.30 - 08.30 Registration and Continental breakfast – Seminar Room I
Session 1 Opening Seminar Room I

08.30 - 08.55	Opening remarks Overview of the workshop	Professor P.K. Raju, Department of Mechanical Engineering, AU
08.55 – 09.15	Collaboration between 2-year and 4-year colleges; SEATEC and LITEE	Ms. Sydney Rogers, Vice President, Nashville State Technical Institute
09.15 – 10.15	Team Life Cycle, Behavior Styles	Professor Chetan S. Sankar, Department of Management, AU, Dr. P.K. Raju

Break - Seminar Room I
Session 2 Design of Field Joint for STS 51-L Case Study - Seminar Room I

10.30 – 11.00	Assignment of Design of Field Joint for STS 51-L; Team formation	P.K. Raju, Chetan S. Sankar
11.00 - 12.00	Case analysis and understanding by participants	All participants of the workshop with assistance from LITEE team

12.00 NOON: LUNCH - Horizons
Session 3 STS 51-L Case Study Presentations - Seminar Room I

1.30 - 2.00	Analysis by teams	All participants of the workshop with assistance from LITEE team and Mr. Roger Boisjoly
2.00 – 3.00	Presentation by	Student teams

	Student teams	
3.00 – 3.30	Question and Answer Session	Workshop participants and Mr. Roger Boisjoly

Break: Seminar Room I

Session 4: Key Note Speech

3.45 – 5.00	**Key Note Speech: Ethics, Integrity, and Professionalism in Engineering Organizations**	**Mr. Roger Boisjoly, Ethics Lecturer, The Space Shuttle Challenger Disaster**
5.00 – 5.15	Assignment of Della Steam Plant Case Study	P.K. Raju, Chetan S. Sankar

6.30 p.m. – Dinner Banquet, Pebble Hill

Feb. 23, 2001

07.00 - 08.00 Registration and Continental breakfast - Seminar Room I
Session 5 Evaluation and Assignment - Seminar Room I

8.00 – 8.45	Assignment of Della Case Study; SMET Links in Della Case Study, Team formation	P.K. Raju, Chetan S. Sankar
8.45 – 9.10	Evaluation and Assessment of Case Studies developed by LITEE	Drs. Gerald and Glennelle Halpin, College of Education, Auburn University
9.10– 9.45	Work Session: Teams meet to discuss the case study	All participants of the workshop with assistance from LITEE team

Break - Seminar Room I
Session 6 Key Note Speech - Seminar Room I

10.00 – 11.30	**Key Note Speech: Effective Team Work Practices for Inquiry-Based Learning**	**Dr. Karl Smith, Morse-Alumni Distinguished Professor, University of Minnesota**

11.45: LUNCH

Session 7 Della Steam Plant Case Study - Seminar Room I

1.00 – 3.00	Work session: Teams meet to discuss the case study and create the presentation	All participants of the workshop with assistance from Dr. Smith and LITEE team

Break – Seminar Room I

Session 8 Della Steam Plant Case Study - Seminar Room I

3.15 - 3.30	Presentation by team 1	
3.30 - 3.45	Presentation by team 2	
3.45 - 4.00	Presentation by team 3	
4.00 – 4.15	Presentation by team 4	
4.15 – 4.45	Decision and Implementation Overview of Instructor's Manual	P.K. Raju, Chetan S. Sankar
4.45 – 5.15	Assignment of In Hot Water: Cooling Tower Case Study	Justin Cochran

5.30 – Dinner on your Own

Feb. 24, 2001

07.00 - 08.00 Horizons Breakfast

Session 9. How to Use Case Studies in your Classroom?: Seminar Room I

8.00 – 8.30	How to use these case studies in your engineering classrooms? What did other instructors find out?	Dr. P.K. Raju, Dr. A. Mishra / Peter Romine
8.30 - 9.00	Demonstration of	Dr. Chetan S. Sankar, LITEE team

	other case studies available to you; Processes through which LITEE will help you administer these case studies in your classrooms.	

Break: Seminar Room I

Session 10. In Hot Water: Cooling Tower Case Study: Seminar Room I

9.15 – 10.15	Group work	Workshop participants
10.15 - 11.15	Group discussion	Workshop participants
11.15 – 11.45	Wrap-Up, Evaluation	P.K. Raju, Chetan S. Sankar

11.50 – Formal Closing of the Workshop