2006-1159: NATIONAL DISSEMINATION OF MULTI-MEDIA CASE STUDIES THAT BRING REAL-WORLD ISSUES INTO ENGINEERING CLASSROOMS: PILOT STUDY

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National Dissemination of Multi-Media Case Studies That Bring Real-World Issues into Engineering Classrooms: Pilot Study

Engineering students are increasingly being asked by potential employers to demonstrate “soft” skills (such as problem solving and business skills) in addition to their “hard” technical skills. Reflecting these expectations, the Accreditation Board for Engineering Education (ABET) has defined a set of accreditation criteria (3a-k) which identify 11 outcomes expected of engineering graduates. The Laboratory for Innovative Technology and Engineering Education (LITEE) team at Auburn University obtained funding from the NSF and, working with industrial partners, has developed award winning multimedia case studies to address these expectations. These case studies make it possible for students to visualize the problem posed in the case study and work in teams as they play the roles of concerned engineers and managers. In class presentations, students present solutions to the problem and defend them. Evaluation data shows that implementing LITEE case studies in classrooms improves the higher-level cognitive skills of students, stimulates teamwork, and satisfies the majority of the ABET 3a-k criteria. Experience gained from disseminating the case studies through the earlier NSF CCLI grants, as well as reports from others, shows that there are many significant challenges in introducing multimedia case studies into engineering classrooms. Some of the challenges are: changes in the role of the instructor, apprehension about using innovative materials, difficulties in evaluating and testing students, and training students to engage in effective teamwork. The goals of this project were derived in order to address these challenges. They are to provide faculty members with hands-on experience of working in teams, explain case study teaching strategies, connect STEM theories to the real-world problems discussed in the case studies, and demonstrate how the LITEE case studies can help meet the ABET accreditation criteria. We have formed a partnership with a group of engineering/technology faculty members, experts in engineering education, and a few industry engineers/managers. These partners play a key role in validating the concept and value of disseminating LITEE case studies to students and training other faculty members. In this project, the partners work with LITEE through holding national conferences and regional workshops. This paper summarizes the results of conducting this project during 2001-2005.

I. Project Description
1.1. Need for Innovative Instructional Materials in Engineering

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, emerging knowledge related to cognitive theory and educational pedagogy, information technology, and many other forces, the approach to engineering education is shifting dramatically. The new approach assumes that every student can learn with the assistance of effective new strategies and practices that increase learning. Instructors are expected to build on the students’ prior experiences, promote high expectations within a supportive climate and encourage inquiry and the excitement of discovery, in addition to embedding communication and teamwork, critical thinking, and life-long learning skills into the learning experience. Active, integrative project-based learning is needed to replace the passive lecture-based instruction that is so common in our classrooms. Engineering students are increasingly being asked by potential employers to demonstrate “soft”
skills (such as problem solving and business skills) in addition to their “hard” technical skills. Reflecting these expectations, the Accreditation Board for Engineering Education (ABET) adopted new accreditation criteria, Engineering Criteria 2000 (EC2000), which identify in Criterion 3 (a) through (k), 11 outcomes expected of engineering graduates.

1.2. Impact of LITEE Case Studies on Engineering Education

Realizing the importance of addressing these requirements, we formed the Laboratory for Innovative Technology and Engineering Education (LITEE) in 1997. A review of literature revealed that the teaching methodologies of lectures, experimental laboratories, design projects, case studies, games, and internships were all likely to achieve the requirements. An analysis of the application of these methodologies to meet the requirements, along with the results from past evaluations of the use of case studies in engineering classrooms, indicated that the case study methodology was the best candidate for bringing real-world issues into engineering classrooms. We obtained funding from the NSF and other sponsors to develop award winning case studies that would help faculty members make the necessary paradigm shift in engineering and technology education so that their graduates are better prepared for the 21st century workplace. Evaluation data shows that the multimedia case studies developed by LITEE have the ability to bring real-world issues into engineering classrooms, improve the higher-level cognitive skills of students, stimulate teamwork among students, and satisfy the majority of the ABET 3a-k criteria in an exemplary fashion.

II.1. Multimedia Instructional Materials Developed by LITEE

The Laboratory for Innovative Technology and Engineering Education (LITEE) team consists of faculty and students from the Colleges of Engineering and Business at Auburn University (usa.edu/research/litee). The team works with industrial partners to identify a suitable problem and bring it alive in the classroom by creating a multimedia case study. This is then tested for pedagogy and content with faculty and students at different institutions. Figure 1 provides a summary of seven case studies developed by the LITEE team. Table 1 lists the Science, Technology, Engineering, and Math (STEM) topics that were used in describing and solving the real-world problem in some of the case studies. These links are showcased in the CD-ROMs and their accompanying textbooks.
### Table 1: Examples of the STEM Competency Materials Included in Case Studies

<table>
<thead>
<tr>
<th>Lorn Textiles (30 slides)</th>
<th>Gears, Motion, Standards (2 slides)</th>
<th>Engineering design, Ethics, Expert Witness (24 slides)</th>
<th>Chart (1 slide)</th>
<th>Legal case, Maintenance (21 slides)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of slides</td>
<td>Science topics as a % of total slides (103 slides; 38%)</td>
<td>Technology &amp; Engineering topics as % of total (191 slides; 70%)</td>
<td>Math topics as % of total (115 slides; 42%)</td>
<td>Business topics as % of total (134 slides; 49%)</td>
</tr>
</tbody>
</table>

**II.2. Case Study Analysis Process**

The case study CD-ROMs make it possible for students to visualize the case study problem and, in some cases, hear the voices of those charged with making the decision in the real world. Photos and videos of the machinery and equipment in the actual plants are included. The LITEE multimedia instructional package also includes a comprehensive instructor's manual in CD-ROM format, which includes solutions adapted from the real world situations with live video footage, animations, teaching suggestions, PowerPoint presentations, and potential exam questions. Both the student version and instructor’s manual include innovative features such as audio clips, video clips, and decision support software.

The time span for a typical multimedia case study implementation in a classroom ranges from one day to five weeks, depending on how the instructor decides to structure the class. The tasks are broken into three phases -- before class, during class, and after class. Prior to the initial class session, the instructor selects the case study to be assigned and provides competency materials to the students. Student preparation for the case discussion involves reading the competency materials and the case studies, and then writing an analysis that follows an instructor-prescribed format. Once the class session has begun, the instructor reviews the competency materials and the case study. Then the instructor divides the class into teams and initiates teamwork exercises, following guidelines from the textbook, to help improve group interaction. Thereafter, the students present their findings. An epilogue discussing how the industry actually dealt with the problem and the outcome provides closure to the class session. Following the class session, the instructor evaluates the students' contributions by reviewing their written recommendations and assigning points to their presentations. Students are tested based on the competency materials and case studies. Evaluation questionnaires<sup>2,6,7</sup> are also included in order to obtain valuable feedback on the utility of the selected case studies from both the students and instructors.

**II.3. Benefits of LITEE Multimedia Case Studies**

Over the past seven years, the benefits of the LITEE multimedia case studies have been evaluated by experts in the College of Education at Auburn University based on the individual contributions of students and overall performances of the teams. In addition, the evaluators have performed longitudinal studies to identify the benefits that accrue from using this case study methodology. The results of the evaluation have been published in numerous journal articles and conference proceedings (<a href="www.auburn.edu/research/litee">www.auburn.edu/research/litee</a>). These studies have established that the benefits of implementing case studies in engineering classrooms are as follows:

- Bring theory and practice together in classrooms
- Facilitate the development of higher-order cognitive skills and problem solving skills in students
- Encourage active teamwork among students
- Bring excitement of real-world problems into classrooms
- Offer insight into STEM topics and how they are actually applied in real-world situations
- Integrate technical, engineering, and managerial issues
• Improve written and oral communications skills
• Foster a change in learning environment that encourages female and minority students to persevere and succeed in engineering programs
• Offer a method that has a lasting impact on student learning, as measured by improved grades in subsequent semesters

In addition to the benefits to students, LITEE multimedia case studies offer significant institutional benefits in that they satisfy the majority of the 11 outcomes specified in the ABET accreditation criteria exceptionally well, improving ties to industry, breaking down departmental/college-level barriers, attracting industry and community sponsors, and encouraging high-school and 2-year college faculty to use the case studies to improve their teaching of science topics.

**III. LITEE Case Studies Dissemination: Need for Faculty Development and Goals of Project**

The experience gained from disseminating the LITEE case studies through the NSF CCLI grants, as well as reports from others\(^{12,29}\), show that even though these materials can be disseminated to other institutions, there are many challenges in using multimedia case studies in engineering classrooms:

(a) *Changes in the role of instructor*: Use of case studies in classrooms implies that the instructor assumes the role of a “guide on the side” instead of the traditional role of “sage on the stage.” The LITEE team has developed videos and instructor manuals that illustrate how this change happens. Professional development activities that inform engineering educators about these materials are essential to encourage them to change the role they play in the classroom.

(b) *Hands-on Analysis of a Case Study*: Instructors need to be able to learn new instructional methodologies without being intimidated. The LITEE workshops provide an ideal mechanism for faculty to work together and perform a hands-on analysis of a case study.

(c) *Recognition for Implementing Case Studies in Classrooms*: The implementation of case studies in a classroom requires a major investment of time and effort from faculty members, who are used to traditional methods of teaching. The proposed project will bring national recognition to the institutions and to the faculty members, thereby motivating them to invest the extra time and effort.

(d) *Apprehension*: Faculty members tend to shy away from using reform-oriented materials in their classrooms due to apprehension about how the students will react to such unconventional instructional materials. Past studies have shown that faculty members need to be trained on a one-on-one basis to learn how to make full use of the special features of new instructional materials. Frequent contact with experts in the education field is also helpful, enabling them to amalgamate new and innovative multimedia instructional materials into education delivery and thus satisfy the requirements of ABET, industries, and society\(^{13,15,30}\). Pilot workshops conducted by LITEE have helped instructors feel less apprehensive and more receptive to using case studies in their classrooms. More information on the pilot workshops is provided in the next section.
(e) Evaluation and Testing: Evaluations of case study presentations is different to those used for traditional engineering education methods that are based on solving problems that have unique solutions. The LITEE team has worked with case study methodology instructors in other fields to develop instruments and methodologies for evaluating case study presentations and these are included in the instructor’s manuals. Developing tests to evaluate whether students have spent time reading and analyzing case studies involves different testing techniques. The LITEE team has also developed methods to address this challenge and will disseminate these materials in the proposed project.

(f) Teamwork Strategies: While some engineering classes encourage teamwork, few courses include opportunities for students to work in teams. The LITEE case studies are an excellent mechanism for students to work in teams (including cross/multi-disciplinary teams) as they attempt to solve a real-world problem. The LITEE team has developed competency materials on teamworking and these will also be disseminated during the proposed project.

These challenges make the case for deriving the goals of the project as follows.:

- Provide hands-on experience in how to adapt and implement LITEE multimedia case studies
- Provide strategies (including use, evaluation, and testing) for the case study methodology of teaching in engineering classrooms
- Demonstrate the connection of science, math, and engineering theories and non-technical issues in solving real-world problems
- Provide opportunities to work in teams and learn from colleagues
- Provide opportunities to visualize the machinery and processes used in industry using information technologies and allow educators to interact with industry managers
- Provide for two-way communication with experts in teaching and student learning
- Demonstrate how LITEE case studies can satisfy ABET accreditation (3a-k) criteria

In the next section, we describe how these goals were met in conferences and workshops held during 2001-2005.

IV. Workshops

During 2001-2005, we conducted six workshops with partial support from the National Science Foundation (DUE # 0001454) to provide faculty with an opportunity to gain hands-on experience with the use of the LITEE multimedia case studies. The feedback and evaluations from these workshops have been extremely positive, and the faculty members (including women, African-Americans, Hispanic-Americans, high school teachers, and community-college teachers) and students who attended the workshops concluded that the instructional materials and methodologies are exemplary, meet the needs of the new educational paradigm, and are worthy of national dissemination. Approximately 250 faculty members and students participated in the six workshops. We provide summary data from five of these workshops which were held in the U.S. and detailed results from the workshop that was held overseas at Santiago, Chile.

Details of the five Workshops held in the U.S.: Each of the five workshops held during 2001-2005 lasted 2-days and included numerous opportunities for participants to have hands-on experience with the multimedia case studies. The participants were provided with individual
computers and a CD-ROM of the case study and worked in teams. They read the textbook, worked on the CD-ROM, worked in teams, discussed their findings with team members, and made presentations that showed possible solutions to the problem posed in a case study. They were also assisted to develop plans for adapting and implementing a LITEE case study in their classrooms. In all of the workshops, engineering education experts and industrial executives participated, critiqued, and worked with the faculty members and student teams.

**Evaluation of the Workshops:** At the end of the workshops, the participants were asked to complete an evaluation form that posed five questions based on the goals stated in Section III, using a rating scale that measured the extent of their agreement/disagreement with statements regarding the workshop. Table 3 provides an analysis of the responses to the five questions for a few of the workshops where 53 participants responded to the questionnaire. The results show that a majority of the respondents either *strongly agreed* or *agreed* to all five evaluation questions. In summary, the industrial sponsors of the case studies, faculty, and experts who attended the workshops expressed their strong support for a national dissemination project. One participant summarized the overall positive response of those attending: “Take this show on the road!”

<table>
<thead>
<tr>
<th>Response Options</th>
<th>Provided Hands-on Experience</th>
<th>Provided Strategies on Case Study Methodology</th>
<th>Demonstrated the Importance of Non-Technical and STEM Issues</th>
<th>Provided Opportunities for Teamworking</th>
<th>Demonstrated the Use of Information Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree (%)</td>
<td>75.5</td>
<td>75.5</td>
<td>66.0</td>
<td>83.0</td>
<td>68.6</td>
</tr>
<tr>
<td>Agree (%)</td>
<td>22.6</td>
<td>24.5</td>
<td>32.0</td>
<td>17.0</td>
<td>31.4</td>
</tr>
<tr>
<td>Disagree (%)</td>
<td>1.9</td>
<td>0</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strongly disagree (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3: Percentages of Participants in Workshops Choosing the Various Response Options: (n=53)

**Report on Assessment of LITEE Workshop, Santiago de Chile, October 2005**

Hispanic Americans are not participating in the fields of engineering, math, and science in numbers that are commensurate with their representation in the American society. We received supplemental funding to our current project (Educating Engineering for the Information Age: A Real-World Case Studies Based Project) so as to add an international dimension to the project and help address the above stated problem. In the proposed project, we conducted a 2-day workshop at Chile where the Spanish version of an award-winning case study and associated competency materials was tested and finalized. The project has the potential to bring real-world into engineering classrooms at Hispanic-serving institutions, improve the higher-level cognitive skills of the students, and provide materials that will meet the requirements of ABET 2000. We had about 40 participants from Chile and 6 participants from the U.S. Most of the participants from Chile were either the deans, heads of department, or senior faculty from the engineering schools. Dr. Susan Kemnitzer, NSF, gave an excellent keynote address for the participants and had a lively Q&A session. We conducted an evaluation of the workshop.

At the end of the meeting, the participants were required to assess the usefulness and organization of the workshop by filling out a questionnaire comprising of 8 items. Items were in put in the form of positive statements about different aspects of the workshop. Examples of some
of the items are “The workshop demonstrated how to bring theory and practice together in classrooms” and “The workshop was well organized”. Responses to each statement were recorded on a 4-point Likert scale ranging from Strongly Agree, Agree, Disagree, and Strongly Disagree.

The responses to the 8 questions indicated that the participants rated the workshop to be highly beneficial and reasonably well organized. There was unanimous agreement or strong agreement among all 37 participants on four of the eight statements. Of particular significance for future workshops in Latin America is the inclusion among these four, of the statements “The workshop has the potential to motivate Spanish-speaking students to pursue engineering education” and “Translating other LITEE case studies into Spanish is valuable for engineering faculty and students”. The LITEE cases were originally conceived to motivate all gifted U.S. students to pursue engineering careers. The fact that the cases are now being put to use in a foreign country, with the potential for further growth, is a major outcome of the Chilean venture. The statement receiving the least positive support involved the organization of the workshop with only 11% of the participants disagreeing or strongly disagreeing that the workshop was well organized.

Participants were also required to write down strengths and weaknesses they perceived about the workshop and to write suggestions to the organizers for future workshops. There was significant agreement on several strengths, weaknesses, and suggestions. For example, 21.6% gave the “integration of theory and practice in the cases” as a strength. This citation was closely followed by “allows interaction with faculty of different universities”, 16.2%, and “global view of the case study and its benefits/of this teaching methodology”, 16.2%. The most frequently cited weakness, by 18.7% of the participants, was “not enough time”, while 13.5% suggested more “real and practical” cases to be included in future workshops. Table 4 gives the assessment feedback by participants in greater detail.

<table>
<thead>
<tr>
<th>Statements</th>
<th>Average score scale 4 (strongly agree) - 1 (strongly disagree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The workshop demonstrated how to bring theory and practice together in classrooms.</td>
<td>3.6</td>
</tr>
<tr>
<td>2. The workshop provided educational strategies to develop higher level cognitive skills in students.</td>
<td>3.5</td>
</tr>
<tr>
<td>3. The workshop provided sufficient information about LITEE case studies.</td>
<td>3.4</td>
</tr>
<tr>
<td>4. The workshop provided instructional materials that help meet ABET criteria.</td>
<td>3.1 (-)</td>
</tr>
<tr>
<td>5. The workshop has the potential to motivate Spanish-speaking students to pursue engineering education.</td>
<td>3.5</td>
</tr>
<tr>
<td>6. Translating other LITEE case studies into Spanish is valuable for engineering faculty and students.</td>
<td>3.8 (+)</td>
</tr>
<tr>
<td>7. I will use LITEE case studies in my classroom if it is available in Spanish.</td>
<td>3.5</td>
</tr>
<tr>
<td>8. The workshop was well organized.</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Table 4: Evaluation of LITEE Workshop
VII. Current Work in Disseminating LITEE Case Studies

The survey results show that the workshop conducted at Chile was an unqualified success. There were some aspects of the conference that need improvement. Some of these were a result of running a conference in a foreign language and in a foreign country for the first time. No doubt, with the lessons learned from this exercise, future conferences of this nature will be just as free of minor problems as conferences held in the U.S. As more workshops are offered, the results will be accumulated and presented. An encouraging finding from the evaluation is that LITEE cases are adaptable. The usefulness of LITEE cases had already been established in the various regions of the U.S. Now, we have evidence that LITEE cases can be very useful for teaching engineering concepts in a foreign country as well.

Based on the success of the workshops we have described in this report, we have formed a partnership with a group of 11 engineering faculty members and 5 educational experts who have attended the workshops and have agreed to participate in disseminating the LITEE case studies further.

Engineering faculty members have agreed to serve as a “core faculty” who will be trained in this methodology and, in turn, train cohort faculty members. Table 5 lists their names, institutions, the case study they intend to adapt and implement in their classrooms and comments on the intellectual merit and broader impact of this project.

<table>
<thead>
<tr>
<th>Name</th>
<th>University / School</th>
<th>LITEE case study to be used</th>
<th>Comments on the Intellectual Merit and Broader Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bala, Radha</td>
<td>Northern Illinois University</td>
<td>Briggs &amp; Stratton</td>
<td>I strongly believe that the LITEE case studies will be of immense value to students of our University as well students from other parts of the state.</td>
</tr>
<tr>
<td>2. Bradley, Randy</td>
<td>Troy State University</td>
<td>Powertel, AUCNET, Chick-fil-A</td>
<td>The majority of our students are full-time employees in companies and students by night . . . The case studies enhance their knowledge base and help them develop problem solving skills.</td>
</tr>
<tr>
<td>3. Darwish, Mukaddes</td>
<td>Texas Tech University</td>
<td>STS 51-L</td>
<td>This project will provide the students, especially, underrepresented groups, the best scientific, technological, and work place literacy and experience, thereby preparing them for real-job environments.</td>
</tr>
<tr>
<td>4. Das, Shuvra</td>
<td>University of Detroit Mercy</td>
<td>STS 51-L, Dell, Briggs &amp; Stratton, Powertel</td>
<td>Through the pre-college programs, these case studies will help in encouraging more minority (both female students and ethnic minorities) to take on the challenges of engineering as a career</td>
</tr>
<tr>
<td>5. Giagola, Charles</td>
<td>University of Florida</td>
<td>STS 51-L</td>
<td>Viewing theory through case studies constitutes a symbiotic relationship where exposure to applications will greatly enhance understanding of theory and the basic principles of students' math and science education.</td>
</tr>
<tr>
<td>6. Hargrove, Keith</td>
<td>Morgan State University (HBCU)</td>
<td>STS 51-L</td>
<td>I look forward to applying a case study in our pre-college summer program, and in two courses since it simulates real-world decision making that our students will eventually face in corporate America.</td>
</tr>
<tr>
<td>7. Ketkar, Mohan</td>
<td>Prairie View A&amp;M University (HBCU)</td>
<td>AUCNET, Della</td>
<td>I am fully convinced that after going through LITEE case study assignments, each student will have a much better understanding of the issues related to decision making and solving real-world problems.</td>
</tr>
<tr>
<td>8. Matin, M.A. and Ojha, Anand</td>
<td>University of Denver</td>
<td>STS 51-L</td>
<td>This project has great intellectual merit as it seeks to involve engineering faculty in training cohort faculty from the STEM disciplines in adopting the case method.</td>
</tr>
<tr>
<td>8. Mbarika, Victor</td>
<td>Southern University</td>
<td>AUCNET, Powertel</td>
<td>This project will integrate for the students engineering and business issues by understanding that good decisions require striking a balance between technical, financial, and credibility issues.</td>
</tr>
<tr>
<td>10. Mohsen, J.P.</td>
<td>University of Louisville</td>
<td>Crist, STS 51-L</td>
<td>The department will benefit by participating in this project in the following ways: meeting specific ABET outcomes and nurturing students by providing them a unique learning opportunity.</td>
</tr>
<tr>
<td>11. Bayratkar, Tuba</td>
<td>Hampton University</td>
<td>Lorn case study</td>
<td>Implementation in a freshman class</td>
</tr>
</tbody>
</table>

Table 5: Profile and Comments of Core Faculty Members
We expect the successful adaptation of the LITEE case studies in other institutions members will improve the way students learn important STEM principles by integrating soft and hard knowledge, provide students with real-life, comprehensive experiences in engineering, make the curriculum more interesting, and enable engineering educators to successfully meet many of the ABET accreditation criteria. In the future, we expect to report on the results of these faculty members implementing LITEE case studies in their classrooms.

**Acknowledgements**

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