**Title:**
Educating Engineers for the Information Age: A Real-World Case Studies Based Project

### Project Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Worked for more than 160 Hours</th>
<th>Contribution to Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raju, P.</td>
<td>Yes</td>
<td></td>
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<tr>
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<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Halpin, Glennelle</td>
<td>Yes</td>
<td>Perform evaluation studies</td>
</tr>
<tr>
<td>Halpin, Gerald</td>
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</tr>
<tr>
<td>Margitu, Daniela</td>
<td>Yes</td>
<td>Assisted in providing computer science support</td>
</tr>
<tr>
<td>Bryant, Don</td>
<td>Yes</td>
<td>Implemented Della case study at high school</td>
</tr>
<tr>
<td>Cochran, Justin</td>
<td>Yes</td>
<td>Provided multi-media support for the project</td>
</tr>
<tr>
<td>Mbarika, Victor</td>
<td>Yes</td>
<td>Provided research support; Implemented case studies at Louisiana State University</td>
</tr>
<tr>
<td>Hoover, Jason</td>
<td>Yes</td>
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**Senior Personnel**

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**Post-doc**

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**Graduate Student**

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<tbody>
<tr>
<td>Hoover, Jason</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Developed CD-ROM for Powertel case study
Name: Patton, David
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed Briggs & Stratton Case Study and CD-ROM

Name: Plank, Chet
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed Lorn Textiles case study

Name: Bliedung, Nadja
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed Briggs & Statton Case study

Name: Kumaraseti, Srinivas
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed Powertel CD-ROM

Name: Satyamoorthy, Vaishnavii
Worked for more than 160 Hours: Yes
Contribution to Project:
Develop teamworking materials

Undergraduate Student
Name: Hamblen, Clay
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducted project with high school

Name: Sankar, Shiva
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed web sites for project

Name: Campbell, Robert
Worked for more than 160 Hours: Yes
Contribution to Project:
Maintained web site information

Name: Colleti, Joey
Worked for more than 160 Hours: Yes
Contribution to Project:
Webmaster

Name: Goss, Kristie
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed Briggs & Statton CD-ROM

Name: Seaton, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:
Develop websites

Name: Bancroft, William
Worked for more than 160 Hours: Yes
Contribution to Project:
Provided web support

Name: Zewdu, Hiwot
Worked for more than 160 Hours: Yes
Contribution to Project:
Provided database support

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Powertel
Powertel engineering and managers provided material that was used in developing a multi-media case study.

Briggs & Stratton
The company provided data and materials to develop a case study.

Two lawyers
Two lawyers provided the information needed to develop the Lorn Textiles case study.

Other Collaborators or Contacts
(a) Faculty members at Nashville State Technical Institute worked with us in writing articles that showed how a case study could be used in a 2-year institution.
(b) Faculty members at Mercer University and Louisiana State University continue to use the case studies in their classrooms.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)
The new fundamentals of engineering include information technology, which will be embedded in virtually every product and process in the future (Wulf, 1998). In order to exploit the synergies, design of products, systems, and services require teams that can integrate information technologies with traditional engineering areas such as fluid mechanics, thermal sciences, materials science, manufacturing technologies, and precision design. In addition, more than 1.3 million new programmers, engineers, systems analysts, and computer scientists will be required between 1996 to 2006 to meet the industry's information technology demands according to a report from the U.S. Commerce Department's Office of Technology (1998). The need to use information technologies to creatively improve undergraduate education is further stressed by the Carnegie Foundation for the Advancement of Teaching (Fortenberry, 2000).

In order to meet these needs, we are conducting this project with the following goals:

(a) develop new case studies that introduce engineering students to the complexity of real-world problems and how engineering companies are working in the information age,
(b) develop instructional materials so that they improve higher-level cognitive-based problem solving ability of the students,
(c) develop multi-media/web-based materials that show engineers working together physically and virtually to solve real-world problems,
(d) test their effectiveness with engineering students at Auburn University, three minority serving institutions, and other Universities, and
business students,

e) develop on a pilot basis, a case emporium that will include a case study technical support repository and provide student teams opportunities to work in a virtual environment, and

f) disseminate the material by conducting workshops for engineering educators, by creation of a case emporium, and publishing in journals and conference proceedings.

Please read through the enclosed file for more details.

Journal Publications


Findings: (See PDF version submitted by PI at the end of the report)

The major findings on conducting this project are: (a) IT materials stimulate the interest for engineering students to study engineering topics, (b) female students get excited about the engineering topics provided IT is used in the delivery of materials, and (c) once convinced that the multimedia case studies are worthwhile, engineering faculty members would find innovative means of integrating these materials in their classrooms as shown in the workshops. Each of these findings is described further in the enclosed file.

Training and Development:

STUDENTS:
The instructional materials have been used to train about 200 engineering students at Auburn University, Alabama A&M, University of Pittsburgh, and Embry-Riddle University. About 1,000 business students at Auburn University and Louisiana State University used it. The evaluations of this training and development sessions are provided under the 'findings' section.

The project also provided research experience and training to 8 undergraduate, 6 graduate, 2 post-graduate students, and 2 instructors who worked for the Laboratory for Innovative Technology and Engineering Education (LITEE). They worked with the faculty members to develop the instructional materials, test them, and administer them. The students from both engineering and business colleges participated in this interdisciplinary project. More details about the research experience gained by the students are provided in the section 'Development of Human Resources.' The students were provided training in engineering, business, and information technologies. This training helped the students to get excellent jobs in industries. More details are provided in the 'contributions to the principle discipline,' section.

FACULTY MEMBERS:
In addition, faculty members from different engineering schools have been made aware of the instructional materials created out of this project in conferences. In addition, interactive workshops were offered at different forums where faculty members participated. These activities created an awareness of using this new methodology in engineering classrooms and led to the adaptation of these materials in other schools.
(b) Conducted a 3-day workshop for 14 managers from U.S. Steel Corporation affiliate, June 6-8, 2001,
(c) Invited to present NSF project results to Program Directors at NSF, April 2001, Washington, D.C.
(d) Showcased the LITEE project at the 2000 ASEE Conference, June 18-21, 2000, St. Louis, MO.
(g) Presented the status of the Laboratory for Innovative and Technology Education (LITEE) at the 2002 ICIS Center Director's Workshop, New Orleans, Dec. 17-19, 2001.
(h) Conducted a workshop entitled, 'Importance of Ethical and Business Issues in Making Engineering Design Decisions: Teaching through Case Studies,' to 15 faculty members at ASEE Southeastern Section, April 7, 2002.
(i) Invited presentation on 'LITEE Case Studies,' at The Case Files Meeting, Aug. 14, 2002.

**Outreach Activities:**

(a) Participated in development and creation of the Business-Engineering-Technology Program at Auburn University. The first group of students were admitted during Fall 2001.
(b) Conducted a workshop at the 2002 Americas Conference on Information Systems thereby informing MIS faculty members about use of science and technology in businesses.
(c) Coordinated the administration of Della Case Study in a physics class at Tallessee High School.
(d) Working with Alabama Cooperative Extension Center to teach physics and information technologies to 4-H students. The objective is to connect physics content with real-world case studies and then provide an opportunity for the students to showcase their work using multimedia authoring tools.

**Journal Publications**


**Books or Other One-time Publications**
Contributions within Discipline:

Principal Discipline of the Project:
Innovation:
1. Innovation in content: The IT-based case studies provided students opportunity for team working and learning from peers. It brings the real-world into the classroom by use of videos, photos, and audio clips.
2. Innovation in organization: The use of multimedia technologies makes it easy for students to cut and paste the charts, photos, and videos in their presentations thereby enhancing the quality of their work.
3. Innovation in presentation: Videos, audios, photos, and animation augment the student's ability to grasp the complex engineering materials and made it possible to connect them to SMET theories. Students used multimedia technologies in their presentations (for example, were able to show a rotor or expert choice results in their presentation). Made it possible to make decisions in a timely manner—Important feature when we consider the limited time that is usually available to make decisions on (sometimes million dollar) problems. It enhances student-centered learning since they are actively involved in solving the problem.
4. Innovation in evaluating effectiveness: The findings section shows that the educational objectives were achieved exceedingly well.
5. Innovation in transferability: The case study materials have been adopted for use at Illinois Institute of Technology, University of Virginia, and at Auburn University. The materials have been also used at the Colleges of Business at Auburn University and Louisiana State University. These show that the instructional materials could be used in different campuses producing similar positive results.
6. Innovation in curriculum development: A Honors undergraduate student in Mechanical Engineering wrote his thesis on connecting physics concepts with the Della Steam Plant case study materials. Similarly, another Honors undergraduate student in MIS wrote his thesis on the virtual teamwork between students at two Universities in solving the Chick-fil-A case study.
7. Innovation in Freshman Curriculum: Based on the materials developed in this project, Dr. Raju has been teaching the 'Introduction to Engineering' to freshman students starting Spring 2000. The materials have been used in this course every semester and approximately 70 students are served. Based on this experience, the researchers have submitted a proposal to Oxford University Press to develop a textbook that incorporates theories, case studies, and projects.
The instructional materials included in this textbook provide an opportunity for students to apply the theories they learn to real-world problems.

The instructional materials in the proposed textbook are organized as follows:
(a) Materials in the chapters help students acquire skills in dealing with technical and non-technical issues that are important in the practice of engineering. The students learn new theories and methods using these materials.
(b) Multi-media CD-ROM case studies provide examples of real-world technical problems that occurred in industries. Using the exercises provided in the CD-ROMs, the students apply the theories learned in the chapters to simulated environments of complex real-world problems. This reinforces the concepts learned earlier and fosters an understanding of engineering practice. The case studies included in this textbook were developed on the basis of work performed under four National Science Foundation Grants, DUE # 9752353, 9950514, 0001454, and 0089036. External evaluation of the use of the case studies have shown that they are highly effective and result in students showing a strong interest in the engineering subject-matter, as indicated by obtaining higher GPAs in subsequent semesters.
(c) Simple engineering projects that could be performed in a course setting are described. The website for the textbook would provide videos, photos, and sample work of student teams who have participated in designing and implementing example engineering projects. Working on these team-based projects would provide hands-on experience to students and show the use of theories learned in solving practical problems. In addition, it would motivate them to participate actively in other engineering courses where advanced theories are discussed.

An unique feature of this textbook is that the instructor will have the flexibility to use appropriate case studies that are suitable for the class depending on the students’ majors. We provide a set of six case studies that relate to industry problems from different disciplines. In addition, suggestions are provided in the textbook for simple projects that could be used along with the textual material and the case studies. The list of projects provided in the textbook is not comprehensive and we encourage the instructors to come up with project ideas other than those provided in the list, depending on their disciplines. We believe we have provided a wealth of material in the chapters and the case studies. Therefore, we expect the faculty members to be able to choose the appropriate mix of chapters, case study exercises, and project assignments in designing their lesson plans so that it meets the needs of their institutions and disciplines.

Contributions to Other Disciplines:
Contribution to Other Disciplines of Science or Engineering:
Based on the success of this innovative methodology, Auburn University has developed a Business-Engineering-Technology program. This program is jointly run by the Colleges of Engineering and Business through the Thomas Walter Center for Technology Management. The center is a joint effort between the engineering and business schools and offers students the option of a minor in either field. In this program, engineering and business undergraduates will take classes together, work in cross-functional teams, learn engineering and business principles, and practice integrating business and engineering principles by solving real-world case studies and design problems. The students who complete the program successfully will earn a minor in ‘Business-Engineering-Technology.’ The program has been operational starting Fall 2001.

Contributions to Human Resource Development:
Development of Human Resources:
This project developed skills of undergraduate students, graduate students, and post-doc fellows. It provided an opportunity to train 7 undergraduate students. Through this project 6 masters students, one doctoral student, and two post-doc fellows were trained. These students describe that the research experience has benefited them academically, personally, and professionally and hope such experiences will be available to other students. They consider working on this project to be a rewarding experience and an extremely valuable educational experience. The students who have graduated report that they were able to get exceptional and multiple job offers and ascribe the work experience at LITEE to be one of the major contributing factors.

Graduate and Undergraduate Thesis and Project Reports:
Student Title Degree, Year
Justin Cochran A Cooling Tower Case Study M.S.M.E., 2000
Vamsee Dasaka Learning from Failure: The SRB Field Joint Redesign M.S.M.E., 2000
Nadja Bleindung IT Used at Briggs & Stratton, Inc. M.S.M.E., 2002
Patrick Klesius Operating Systems Decision at Chick-fil-AMMIS, 2001
David Patton Integrating AUCNET Case study in a Telecommunications Class MMIS, 2002
Justin Williams PowerTel: Cell Site Construction Case Study MMIS, 2001
Clay Hamblen Implementing Della Case Study in a Physics Class B.S. Honors, 2002
Andy Redman Use of Virtual Teams to Collaborate on Analyzing Chick-fil-A Case Study B.S. Honors, 2002
Chet Plank Lorn Textiles: Emphasis on Safety and Design M.S.M.E., 2002
Victor Mbarika Analysis of the Effectiveness of Multimedia Technologies Ph.D., 2001
LaTonia Alexander Applying the System Development Life Cycle to Create a CD-ROM to be used in a Real-Life Setting MMIS, 2000

The undergraduate and graduate students trained through this project are currently employed by companies such as IBM, MicroStrategy, Price
Contributions to Resources for Research and Education:
Contributions to the Physical, Institutional, and Information Resources that form the infrastructure for Research and Education:
The project has enabled the Laboratory for Innovative Technology and Engineering Education (LITEE) at Auburn University to use office spaces in both the Colleges of Engineering and Business. Computers, TV, VCR, and needed software have been purchased in order to develop the physical infrastructure needed for the project.

In addition, the project has led to creation of information resources that form the basis for the infrastructure for research and education. Two major activities have taken place under this category:
(a) A new journal entitled, Journal of SMET Education: Innovations and Research, has been created with a mission to meet the need for high-quality case studies and papers that integrate real world issues with theories in engineering, business, mathematics, and science subjects. This journal has been well received by the engineering and SMET educators.
(b) Research has been performed to identify the factors that lead to success of the methodology in the engineering classrooms. A major finding is that learning-driven constructs such as challenging students, enhancing their learning interest, providing opportunities for learning from others, and improving the ability to learn from oneself are important considerations in designing the instructional materials. Research papers have been published in journals and these information resources would not only help this project, but other projects that develop innovative instructional materials.

Contributions Beyond Science and Engineering:
Contributions Beyond Science and Engineering:
The materials are being used every semester at courses at the College of Business at Auburn University and Louisiana State University (LSU). The researchers at LSU have integrated some of these case studies in the Introduction to MIS course in the MBA program thereby showing non-technical students the relevance and importance of engineering and technical disciplines.

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Unobligated funds: less than 20 percent of current funds
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:
Findings

The major findings on conducting this project are: (a) IT materials stimulate the interest for engineering students to study engineering topics, (b) female students get excited about the engineering topics provided IT is used in the delivery of materials, and (c) once convinced that the multimedia case studies are worthwhile, engineering faculty members would find innovative means of integrating these materials in their classrooms as shown in the workshops. Each of these findings is described further below.

**IT Materials Stimulate the Interest of Engineering Students about Engineering Topics**

The three case studies described in the activities section were used in multiple engineering classes at Auburn University, Mercer University, Illinois Institute of Technology, University of Virginia, and other institutions. The results of evaluation show that the materials are well received by students if the IT technologies are integrated with case studies. Further evaluation efforts are under way and we will report on those results next year.

**Female Students get Excited about the Engineering Topics Provided IT is used in the Delivery of Materials**

A paper that is scheduled to appear at the IEEE Transactions on Education revealed that female students get excited about engineering topics provided IT is used in the delivery of materials and is used to enhance their learning-driven factors.

Past research has shown that females have more negative attitudes toward engineering and technology than do males. These negative attitudes may explain the decreasing number of females choosing technical careers. Past studies have shown that a change in learning environments and the methods by which learning takes place might foster a change in this situation. A multimedia case study incorporating a real-world engineering and technical problem faced by a power plant was developed in order to provide a new learning environment for engineering and business students. This research investigates whether the use of this material by female and male students led to differences in perceived higher-level cognitive skills and, if so, seeks to identify the factors that cause the difference.

A research model was developed to show the potential relationships between gender and higher-level cognitive skill improvement with two intervening variables of learning-driven factor and content-driven factor. The Learning-Driven Factor is composed of constructs that show the intrinsic value of the instructional materials to the end-user. The Learning-Driven Factor also explains how the multimedia instructional materials were used as a tool to challenge the end-user in learning difficult management and engineering topics, in connecting theories and practice, in improving students’ understanding of basic concepts, and in providing the students a platform to learn from one another. Content-Driven Factor is composed of constructs that measure the extrinsic value provided to the end-user by the use of multimedia instructional materials. The end-user has no control over the design of this factor. This factor constitutes the technical quality
of the multimedia instructional material, how easy it is to use and locate information contained on the instructional material, and how the design of the instructional material helped to make it easier and more feasible to complete assigned tasks in a timely manner. The constructs and items used to measure these two factors are shown in Table 1.

Table 1: Constructs and items used to measure learning-driven and content-driven factors

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
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<tbody>
<tr>
<td>Factor B: Self Reported Learning</td>
<td>Improved my understanding of basic concepts, learned new concepts,</td>
</tr>
<tr>
<td>(3 items)</td>
<td>learned to identify central management and technical issues.</td>
</tr>
<tr>
<td>Factor B: Learning Interest</td>
<td>Discussed technical and managerial issues outside of class, did</td>
</tr>
<tr>
<td>(3 items)</td>
<td>additional reading on technical and managerial issues, did some</td>
</tr>
<tr>
<td>Factor B: Learned from Others</td>
<td>Learned to value other students’ point of view, learned to inter-</td>
</tr>
<tr>
<td>(2 items)</td>
<td>relate important topics and ideas.</td>
</tr>
<tr>
<td>Factor B: Challenging learning</td>
<td>Brought real life problems successfully to the classroom,</td>
</tr>
<tr>
<td>(4 items)</td>
<td>challenging, helpful in learning difficult topics, helpful in</td>
</tr>
<tr>
<td>Factor C: Timeliness (2 items)</td>
<td>Completed tasks on time, case study reports delivered on time.</td>
</tr>
<tr>
<td>Factor C: Ease of use (3 items)</td>
<td>Learned easily, easy to use, had enough training to use the case</td>
</tr>
<tr>
<td>Factor C: Quality (6 items)</td>
<td>Was current, up to date, data needed available, useful,</td>
</tr>
<tr>
<td>Factor C: Location (4 items)</td>
<td>Was easy to find, easy to locate data, obvious, exact definitions</td>
</tr>
<tr>
<td></td>
<td>of terms were available.</td>
</tr>
</tbody>
</table>

Two questionnaires collected information from 140 students who participated in the experiment (99 men and 41 women). A structural equations model was used to compute the coefficients of the relationship indicated in the research model. An analysis of the results from the model shows that both groups perceived an improvement in the learning-driven factor. Female students valued the learning-driven factor more highly than their male counterparts suggesting that it is improvements in the actual learning process triggered by the system that is more important for this group. The results suggest that when designing new learning...
environments, it is important for the female students to be challenged and have opportunities both to learn by themselves and to learn from others. These results have implications for teaching programs, such as the provision of opportunities for group learning, especially for female students.

**Once convinced that the case studies are worthwhile, engineering faculty members find innovative means of integrating these materials in their classrooms as shown in the workshops.**

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 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. We improved on these workshops and integrated IT much more in the March. 2002 workshop. 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 section, 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.

**Workshop Evaluations March 21-23, 2002**

**TALLY SHEET**

For the following items, circle the choice that most closely indicates your extent of agreement using the following scale:

A.  Strongly Agree          B.  Agree          C.  Disagree          D.  Strongly Disagree

| 1. The workshop demonstrated how to bring theory and practice together in classrooms. |
|---|---|---|---|
| A.  Strongly Agree | B.  Agree | C.  Disagree | D.  Strongly Disagree |
| 10 | 7 | 1 | 0 |

Findings: 3
2. The workshop provided educational strategies to develop higher level cognitive skills in students.
   A. Strongly Agree   B. Agree   C. Disagree   D. Strongly Disagree
   9          9          0          0

3. The workshop provided materials that can help meet ABET 2000 Criteria.
   A. Strongly Agree   B. Agree   C. Disagree   D. Strongly Disagree
   8          7          1          0

4. The workshop provided guidelines on using these materials in classrooms.
   A. Strongly Agree   B. Agree   C. Disagree   D. Strongly Disagree
   8          9          1          0

5. The workshop encouraged active teamwork.
   A. Strongly Agree   B. Agree   C. Disagree   D. Strongly Disagree
   17         1          0          0

6. The workshop helped me evaluate and assess the value of using innovative instructional materials.
   A. Strongly Agree   B. Agree   C. Disagree   D. Strongly Disagree
   8          9          1          0

Please respond in writing to the following prompts using the other side of this form if needed:

Comments from Workshop Participants

Strengths of the workshop:

- to reach wider and diverse audience, keynote & Distinguished Lectures, interactions facilitated by the workshop leaders on variety of issues
- several well prepared complete case studies with extensive technical detail
- excellent time management, start – stop on schedule, got to know other participants, excellent materials
- excellent conference, strong organization, personal introduction, excellent agenda, plenty to drink (water, juice, coffee), excellent speakers, thoroughness, diversity of pieces, excellent software
- The outside speakers were important.

Findings: 4
• This workshop was instrumental in demonstrating methods of incorporating these new materials into existing courses. The speakers were incredible, esp. Rich Felder and gave me a renewed enthusiasm for updating and bettering my university’s curriculum.

• case studies, different perspectives into the case studies

• hands-on, very supportive structure, feel like you accomplished something not merely learned something about active learning methods

• This workshop is well run and well organized. I was very impressed the workshop’s ability to disseminate the case studies produced at Auburn. PK and Chetan have developed a 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 or implement the materials into the curriculum. Surrounding this, PK and Chetan have wrapped very interesting speakers like Rich Felder, Glen Olson, and Sydney Rogers. In all, well done.

• breadth of people and activities, well organized

• Excellent introduction to case studies and their role and importance to engineering education. Program open for collaboration with other individuals and universities.

• the participation of the participants in terms

• good format, keeping participants active and involved, excellent array of presenters, allowed time for networking among participants

• teamwork style – in particular, the team selection process (DISC), excellent presentations (Pimmel, Wulf, Felder, Aldridge, Glennelle, & Gerald Halpin), Glen Olson was excellent

• great projects for mechanical engineering students

• Great Job!

• I hope to come back with other faculty. Will recommend highly to others in our system and college

• comment: The workshop was inspirational to me as a junior faculty struggling with the problems of conventional engineering education and little experience to

Findings: 5
Congratulations to PK, Chetan, Jan and all your fine students on another terrifically successful LITEE workshop. The speakers were excellent and the program design created a great vehicle for learning about ways to adapt LITEE cases to new educational endeavors. It’s amazing that you were able to top the program that I had attended six months ago in September.

I wanted to express how awed and impressed I was by Dr. Wulf’s vision as well as yours in inviting his contributions to the program. This was simply an outstanding workshop that continues to make giant strides in developing the science, math, engineering, and technology education of the future. I am proud of our association and grateful for the opportunity to participate.

Weaknesses of the workshop:

- diversity of cases, get raw materials & ask participants to develop case study – some skills in that development
- too much sitting
- seating, slowdowns on the in-class process presentation, more “how you do it” information and an overview of problems that you have encountered and solved on your way to this excellent work
- time allotment for the case studies
- nothing glaring – minor issue is presentation tech, maybe you could set up “standard’s” and process to show loading of disc’s etc., maybe a second wireless mike to reduce speaker transfer time
- link to math/science/engineering science is not yet clear
- case studies still in development stages SMET content needs further consideration, doesn’t really cover most needs of student
- need more diversity in participants
- It is directed to mechanical engineering type projects exclusively

Suggestions for change:

Findings: 6
Findings: 7

• more examples of how to evaluate individual students – that worked in a group
• would like to have seen Auburn
• focus is more on use of developed case study; some component in how it can be developed, what all is needed to do that would be useful so that faculty get skills on developing such material
• include tour of Auburn Engineering Facilities, mail case studies to participants in advance, reduce page count for course “inserts”
• spaces where people can sit closer together or better arrangement of seating when collaborating on a problem
• send the case studies book & CD in advance to the participants, incorporate ergonomics and safety engineering
• I don’t see how theory is here yet.
• workspace in setting where workshop was given wasn’t best suited for both presentation and computer use
• The workshop lasted too long. could end on Friday afternoon to enable participants to get home before Friday night and not Saturday night, recall some participants left Friday afternoon
• none - great job
• add projects for other areas of engineering

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. We are working with educators from different institutions helping them develop Adaptation & Implementation grants. In addition, we have plans to apply for a national dissemination grant during the next year proposal cycle.

Summary and Conclusions

These findings show that the addition of IT technologies to the 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. In addition the use of IT to illustrate the case studies seem to have a high potential for improving science and math education at high school and informal levels.

References


Research and Education Activities

Introduction: This section provides the goals and educational objectives of this project, the methodology that was used to achieve the objectives, the creation of deliverables, and their administration in engineering and business classrooms at Auburn University and at other institutions.

The new fundamentals of engineering include information technology, which will be embedded in virtually every product and process in the future (Wulf, 1998). In order to exploit the synergies, design of products, systems, and services require teams that can integrate information technologies with traditional engineering areas such as fluid mechanics, thermal sciences, materials science, manufacturing technologies, and precision design. In addition, more than 1.3 million new programmers, engineers, systems analysts, and computer scientists will be required between 1996 to 2006 to meet the industry's information technology demands according to a report from the U.S. Commerce Department's Office of Technology (1998). The need to use information technologies to creatively improve undergraduate education is further stressed by the Carnegie Foundation for the Advancement of Teaching (Fortenberry, 2000).

In order to meet these needs, we are conducting this project with the following goals. Appendix E shows a flow chart to achieve the goals of this project:

(a) develop new case studies that introduce engineering students to the complexity of real-world problems and how engineering companies are working in the information age,
(b) develop instructional materials so that they improve higher-level cognitive-based problem solving ability of the students,
(c) develop multi-media/web-based materials that show engineers working together physically and virtually to solve real-world problems,
(d) test their effectiveness with engineering students at Auburn University, three minority serving institutions, and other Universities, and business students,
(e) develop on a pilot basis, a case emporium that will include a case study technical support repository and provide student teams opportunities to work in a virtual environment, and
(f) disseminate the material by conducting workshops for engineering educators, by creation of a case emporium, and publishing in journals and conference proceedings.

Goals And Educational Objectives:

The goals and educational objectives of this project are shown in Table 1 below.
Project Goals (What will we do?) | Educational Objectives (What will students achieve?)
--- | ---
Develop course materials that introduce engineering students the complexity of real-world problems and how engineering companies are working in the information age | The students will be expected to:
- learn how companies embed information technologies in the design of products and systems and start using the technologies to a limited extent.
- learn how companies incorporate decision-making software to improve engineering decision-making and start using the software to a limited extent.
- work on teams thereby enhancing their team building, interaction, and interdisciplinary skills.
Develop course materials to improve higher-level cognitive-based problem solving of the students. | The students will be expected to:
- identify criteria to solve problems in unstructured situations
- analyze alternatives given multiple criteria
- differentiate between alternatives
- evaluate alternatives
- synthesize relevant materials into defensible solutions to problems
- present a solution persuasively
- be actively involved in learning situations
Develop multi-media/ web-based materials that help visualize engineers and managers solving real-world problems in virtual environments. | The students will be able to have:
- Synchronous learning opportunities such as triggering learning interest, learning from others, and working in teams.
- Asynchronous learning opportunities such as solving challenging problems, accessing vast information sources, learning discovery-based educational experiences safely, and enhancing peer-to-peer education.

Table 1: Educational Objectives to Achieve Project Goals

Tasks Performed in this Project

We worked with three industry partners to highlight how IT is used in industry. The tasks performed during 2001-2002 are: (a) development of case studies and creation of competency materials that show how engineering companies are working in the information age, (b) development of multimedia/ web-based materials that show engineers and managers working in teams and solving real-world problems, and (c) customization of materials and pilot testing in the classroom. Each of these tasks is described next.

Development of case studies and creation of competency materials.
We established contacts with industry partners who were willing to work with us in creating the case studies needed for this project. Each case study was developed by Drs. Raju and Sankar working with the industry partners. This process involved identifying the objectives, creating discussion questions and answers, identifying expected analysis,
researching the theoretical engineering and IT knowledge needed to solve the problem, and obtaining references. The case studies are framed around critical problems facing engineers, managers, and technical personnel in the company. The researchers and students visited the industry and talked to the engineers and managers in order to learn about the problem first-hand. The authors then recorded these conversations and later had them transcribed into textual material. This material formed the basis of creating the first iteration of the written case study and instructor’s manual. These draft case studies were reviewed by a Review Board consisting of industry partners and faculty in engineering and business. Input from these groups was used to revise the cases and create the final version.

The following case studies that had been developed earlier as part of DUE #9950514 were modified further to fulfill the objectives of this grant.


AUCNET USA (E-Commerce Company): Use of satellite technology versus Internet by an on-line auto auction company.

In addition, the following new case studies have been developed:

Briggs & Stratton (major small engine manufacturer): Shows the integration of information technologies used by engineers and business processes in achieving the goals of the company.

Lorn Textiles (textile machinery user): Shows the legal, safety, and ethical issues involved when a textile machinery worker loses four fingers when maintaining the machine

Powertel (Provider of cell telephone services): Illustrates the issues involved in selection of sites where cell towers will be erected. Brings out capacity versus cost considerations.

Competency materials and CD-ROM are being developed for each case study so that the students from engineering, and business would be able to understand and analyze the case study given their educational background.

**Creation of multimedia courseware.** Information technologies was creatively used to develop CD-ROMs for each case study. The CDs have videos of engineers and managers discussing the problems, audios discussing technical elements, pdfs of actual documents, and diagrams. Hyperlinks between the competency material, the case study, photos, and videos of the problem have been created. The CD-ROM provides students access to these materials at their homes and offices so that asynchronous learning can take place. Multimedia technologies allow the participants to see the connections between the various SMET disciplines, real-world problems, and decision-making principles. Opportunities for synchronous learning are provided when the students chat, discuss, and debate these topics in the classrooms. Thereby, opportunities are provided for the students to improve their higher-level cognitive skills and learn more about each of the
SMET disciplines and their connections and contributions in solving real-world problems.

Two laboratories (one in the College of Engineering and another in the College of Business) have been created so that the multimedia CD-ROMs could be developed using the latest hardware and software technologies. Drafts of the CD-ROMs for the three new case studies have been developed.

**Administering the Case Studies in Engineering and Business Classrooms:** During 1999-2002, the Crist, Chick-fil-A, and AUCNET case studies have been used every semester in two engineering courses (ENGR 1110: Introduction to Engineering and ENGR 2210: Engineering Design) and two business courses at Auburn University (MNGT 3040: Telecommunications Management and MNGT 4850: Competitive Strategies through Information Technologies. In addition, the case studies have been used at other Universities such as Illinois Institute of Technology, University of Virginia, Rose-Hulman Institute, Indiana University Purdue University, Louisiana State University, and Mercer University.

We are planning to integrate the three new case studies in the curriculum starting Fall 2003. In addition, we are proposing use of these case studies in a new textbook entitled: Introduction to Engineering through Real-World Applications.

**Conducting workshops to disseminate the results of the research project:** We also conducted one workshop during 2002 in order to disseminate the results of this project to faculty members from other engineering schools. About 30 participants have benefited from these workshops.

**SUMMARY:** The NSF project has resulted in the revision of three case studies and production of three multi-media case studies and dissemination efforts so that other faculty members could have hands-on training on use of these materials. We have plans to develop other case studies in the future as part of this project.
Appendix E: Project Flowchart

Proof of Concept Project
Crist Multimedia Case Study

Industry Partners
- Robert Bosch
- GKN
- Anderson Consulting
- Powertel
- Infonautics

Students

National Recognition

Educators

Industry Executives

Feedback

Proposed Project
Development of Multimedia Case Studies - CD-ROM & Web Based

Industry Partners
- Southern Nuclear
- Silicon Valley Group, Inc.
- NASA
- Hoerbiger
- Mercedes-Benz

Information Technology Experts

Business

Customize
Establish Relationship of Each Case Study to Information Technology

Engineering

Students

Industry Executives

Feedback

Test in Classes

Embry Riddle
- Mercer
- Engineering
- NCA&T
- Business

Auburn

Alabama A&M

Rose-Hulman

Tuskegee

Evaluation and Feedback

Revise Multimedia Case Studies

Dissemination