Principal Investigator: Raju, P. K.
Organization: Auburn University
Title: Educating Engineers for the Information Age: A Real-World Case Studies Based Project

Project Participants

Senior Personnel

Name: Raju, P.
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Sankar, Chetan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Halpin, Glennelle
Worked for more than 160 Hours: Yes
Contribution to Project: Perform evaluation studies

Name: Halpin, Gerald
Worked for more than 160 Hours: Yes
Contribution to Project: Perform evaluation studies

Name: Margitu, Daniela
Worked for more than 160 Hours: Yes
Contribution to Project: Assisted in providing computer science support

Name: Bryant, Don
Worked for more than 160 Hours: Yes
Contribution to Project: Implemented Della case study at high school

Post-doc

Name: Cochran, Justin
Worked for more than 160 Hours: Yes
Contribution to Project: Provided multi-media support for the project

Name: Mbarika, Victor
Worked for more than 160 Hours: Yes
Contribution to Project: Provided research support; Implemented case studies at Louisiana State University

Graduate Student

Name: Hoover, Jason
Worked for more than 160 Hours: Yes
Contribution to Project:
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: 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

Name: Cumbie, Barry
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed systems to support the project

Name: Pujari, Anurag
Worked for more than 160 Hours: Yes
Contribution to Project:
Developed systems for the project

Undergraduate Student
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

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Powertel
Powertel engineers 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 information needed to develop the Lorn Textiles case study.

Crist Power Plant
The management of Crist Power Plant helped us develop the case study and attended sessions when the case study was presented in the classes.

Chick-fil-A
The management of Chick-fil-A worked with the LITEE team to develop the case study. The managers visited classes where the case study was presented and interacted with the students.

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.
(c) We formed partnership with 20 institutions and 22 faculty members representing them. They have expressed strong desire to use the LITEE materials in their classrooms. Further information about their support is provided in the www.auburn.edu/research/litee/corefaculty website. Additional information about the dissemination activities are discussed later in this report.
(d) LITEE was selected as a CASEE (Center for Advancement of Scholarship in Engineering Education) Implementation Network Affiliate by the National Academy of Engineering (NAE).
(e) American Society of Engineering Education (ASEE) has agreed to be a partner with LITEE in disseminating case studies.

Activities and Findings

Research and Education Activities:
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 have accomplished the following tasks as related to the goals stated in the project:

(a) Goal 1: develop new case studies that introduce engineering students to the complexity of real-world problems and show how engineering
companies are working in the information age,

Accomplishment: Developed Chick-fil-A case study to show the importance of operating systems in a fast-food business. Developing an instructor's manual. 

Developed Powertel case study that discusses the design and construction of cell towers in response to higher market demand for wireless communication. Developing an instructor's manual. 

Developing Briggs & Stratton case study to show how engineering and business information systems (such as ProE, SAP R/3) are integrated in the design and manufacturing process of a small engine. 

Developed Lorn case study in order to showcase the importance of legal issues and the role of engineers as legal expert witnesses. 

(b) Goal 2: develop instructional materials so that they improve higher-level cognitive-based problem solving ability of the students, 

These case studies have been implemented in computer science, engineering, and business programs at Auburn University, Louisiana State University, Troy State University, and Columbus State University. Evaluation results show the use of these materials improved the higher-level cognitive skills of students. 

(c) Goal 3: 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, 

The Chick-fil-A case study was administered in a virtual teamwork environment between students at Auburn University and Louisiana State University. 

(f) Goal 4: disseminate the material by conducting workshops for engineering educators, by creation of a case emporium, and publishing in journals and conference proceedings. 

A total of 12 workshops were held during this year to disseminate the materials to 200 faculty members. In addition, six journal articles and five conference articles were published during this period. 

Findings: 

The major findings on conducting this project are: (a) Multimedia materials stimulate the interest in engineering students to study engineering topics, (b) female students got excited about engineering topics when multimedia instructional materials were used, (c) once convinced that the multimedia case studies are worthwhile, engineering faculty members found innovative means of integrating these materials in their classrooms, (d) business students find the LITEE materials to be helpful in understanding technical and engineering concepts, and (e) national organizations such as NAE and ASEE see value in these materials and are willing to work with LITEE to disseminate them to larger groups of faculty members. 

Training and Development: 

Training and Development 

STUDENTS: 

During this period, the instructional materials have been used to train about 500 engineering students at Auburn University, Mercer University, IUPUI, and Rose-Hulman Institute of Technology. About 400 business students at Auburn University and Louisiana State University were also trained with these materials. In addition, the materials were used in a magnet school at Georgia in a physics classroom. 

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: 

Faculty members from about 30 engineering schools have been trained in the use of these instructional materials at multiple 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. 

(1) Sept 7, 2002; Fruitful Experiments: Energy Warrior Camp; Duration: 1 day; Birmingham, AL; 4-H Students; Number of attendees: 24 

(2) April 7, 2002; Bringing Real-World Issues into Engineering Classrooms; Duration: 2 days; Gainsville, FL; Faculty members at ASEE Southeastern Conference; Number of attendees: 20
(3) May 14-15, 2002; Presentation of NSF project results.; 1 day; Washington D.C.; Program Directors; Number of attendees: 30

(4) June 16-18, 2002; Editorial roundtable; 0.5 day; Montreal, Canada; Faculty members at ASEE conference; Number of attendees: 12

(5) June 13, 2002; LITEE Case studies; 0.5 day; Auburn, AL; Muscle Shoals Community College; Number of attendees: 21

(6) August 8, 2002; Real-World issues into MIS Classrooms; 0.5 day; Dallas, TX; Faculty members at Americas Conference on Information Systems conference; Number of attendees: 15

(7) August 14, 2002; Case Studies for 2-year colleges; 0.5 day; Nashville, TN; Nashville State Technical Community College; Number of attendees: 20

(8) Oct. 1-3, 2002; LITEE Project results; 0.5 day; Washington, DC, Engineering & Computing Education Grants conference; Number of attendees: 30

(9) Feb. 24-25, 2003; Bringing Real-World Issues: National Dissemination Proposal; 3 days; Auburn, AL; LITEE workshop; Number of attendees: 30

(10) March 16-18, 2003; Bringing Real-World Issues into Engineering Classrooms; 0.5 day; Phoneix, AZ; Share the Future IV Conference; Number of attendees: 15

(11) March 27, 2003; Bringing Real-world Issues into IT Classrooms: A Multimedia Case Study Approach; 0.5 day; Society for Information Technology and Teacher Education; Albuquerque, NM; SITE Conference; Number of attendees: 4

(12) April 6, 2003; Using Case Histories for Teaching Design; 0.5 day; Macon, GA; ASEE Southeastern Conference; Number of attendees: 4

Total: 12 workshops: Number of attendees: 201

**Outreach Activities:**

- Participated in development and creation of the Business-Engineering-Technology Program at Auburn University.
- Organized a minitrack on IT in Education at the 2003 Americas Conference on Information Systems thereby informing MIS faculty members about use of science and technology in businesses.
- Coordinated the administration of Della Case Study in a physics class at Wheeler Magnet School, Marietta, GA.
- 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


Web/Internet Site

URL(s):
www.jstem.org
www.introtoengr.org
www.auburn.edu/research/litee

Description:
These sites provide information about
(1) the Journal of SMET Education: Innovations and Research and provides the abstracts of published articles.
(2) examples of how the case study materials could be used in an introduction to engineering course,
and (3) provides the official link to the LITEE website.

Other Specific Products

Product Type: web site

Product Description:
The publisher of our textbooks has created a website:
www.etcases.com

Sharing Information:
Instructors who are interested in using the case study materials can order desk copies of the case studies through this website from the publisher.

Contributions
Contributions within Discipline:
Principal Discipline of the Project:
Innovation:
1. Innovation in content: The multimedia case studies provide students opportunity for team working, problem solving, decision making, 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, audio, photos, and animation augment the student's ability to grasp the complex engineering materials and made it possible to connect them to STEM theories. Students use multimedia technologies in their presentations (for example, were able to show a rotor or expert choice results in their presentation). Makes 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 involving millions of dollars) problems. It enhances student-centered learning since they are actively involved in solving the problem.
4. Innovation in evaluating effectiveness: In addition to the formal evaluation by the educational evaluators, two faculty members, Victor Mbarika and Randy Bradley have been conducting extensive research in evaluating the effectiveness of the methodologies and have published many articles based on their work.
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. Dr. Victor Mbarika and Dr. Egbelu of Louisiana State University obtained an NSF A&I award and are adapting and implementing these materials in their engineering and business classrooms.
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. The Briggs & Stratton case study was presented at the SAP Innovation Forum.
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. Other instructors have been using the textbook and methodology in teaching these students.

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 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 web site for the textbook (www.introtoengr.org) provides 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.

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 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 earn a minor in 'Business-Engineering-Technology.' The program has been operational starting Fall 2001 and the first batch of students have graduated during Spring 2003.
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 10 undergraduate students. Through this project 8 masters students, three doctoral students, 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:

<table>
<thead>
<tr>
<th>Student</th>
<th>Title</th>
<th>Degree, Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justin Cochran</td>
<td>A Cooling Tower Case Study</td>
<td>M.S.M.E., 2000</td>
</tr>
<tr>
<td>Vamsee Dasaka</td>
<td>Learning from Failure: The SRB Field Joint Redesign</td>
<td>M.S.M.E., 2000</td>
</tr>
<tr>
<td>Nadja Bleindung</td>
<td>IT Used at Briggs &amp; Stratton, Inc. M.S.M.E., 2002</td>
<td></td>
</tr>
<tr>
<td>Patrick Klesius</td>
<td>Operating Systems Decision at Chick-fil-AMMIS</td>
<td>2001</td>
</tr>
<tr>
<td>David Patton</td>
<td>Integrating AUCNET Case study in a Telecommunications Class MMIS</td>
<td>2002</td>
</tr>
<tr>
<td>Justin Williams</td>
<td>Powertel: Cell Site Construction Case Study</td>
<td>MMIS, 2001</td>
</tr>
<tr>
<td>Clay Hamblen</td>
<td>Implementing Della Case Study in a Physics Class</td>
<td>B.S. Honors, 2002</td>
</tr>
<tr>
<td>Andy Redman</td>
<td>Use of Virtual Teams to Collaborate on Analyzing Chick-fil-A Case Study</td>
<td>B.S. Honors, 2002</td>
</tr>
<tr>
<td>Chet Plank</td>
<td>Lorn Textiles: Emphasis on Safety and Design</td>
<td>M.S.M.E., 2002</td>
</tr>
<tr>
<td>Victor Mbarika</td>
<td>Analysis of the Effectiveness of Multimedia Technologies</td>
<td>Ph.D., 2001</td>
</tr>
<tr>
<td>LaTonia Alexander</td>
<td>Applying the System Development Life Cycle to Create a CD-ROM to be used in a Real-Life Setting</td>
<td>MMIS, 2000</td>
</tr>
<tr>
<td>Xajiong Xue</td>
<td>Information Technology Outsourcing and Virtual Team Doctoral Paper Requirement</td>
<td>Spring 2003</td>
</tr>
</tbody>
</table>

The undergraduate and graduate students trained through this project are currently employed by companies such as IBM, MicroStrategy, Price Waterhouse Coopers, Duke University, PeopleSoft, Powertel, University of Pennsylvania, Shell, Louisiana State University, Troy State University, GE, and Anderson Consulting.

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. Two plasma monitors have been purchased in order to encourage collaborative work among the researchers and students employed in the project. Digital cameras have been purchased so that K-12 and undergraduate students could take photos and incorporate them in their presentations.

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 STEM 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 since 2000. 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 thereby providing an ability for the information resources to not only help this project, but other projects that develop innovative instructional materials.

(c) Faculty members from many different institutions have agreed to work with us to refine and disseminate the methodology and instructional materials in their classrooms. The adaptation of case study method in engineering education is expected to fulfill many of the requirements of ABET 2000 criteria.

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, Troy State 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. Researchers at Texas A&M University are investigating the use of these materials in their distance education programs.
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: