Contact Information for Project

PI Information:
P. K Raju; Auburn University
Educating Engineers for the Information Age: A Real-World Case Studies Based Project

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Graduate student(s): Jason Hoover
Post-doc(s): Victor Mbarika
Graduate student(s): David Patton
Undergraduate student(s): Shiva Sankar; Robert Campbell; Joey Colleti; Kristie Goss
Graduate student(s): Srinivas Kumaraseti; Vaishnavi Satyamoorthy
Undergraduate student(s): Daniel Seaton
Senior personnel(s): Don Bryant
Undergraduate student(s): William Bancroft
Graduate student(s): Barry Cumbie; Anurag Pujari
Senior personnel(s): Lynne Rose
Graduate student(s): Ahuja Nitesh; Katakam Narendranath; Harris Nicole; McLaurine William
Undergraduate student(s): Allan Drew; Kensey Mark
Senior personnel(s): Howard Clayton
Graduate student(s): Phani Virabadra
Research Experience for Undergraduates(s): David Jackson; Erin Allen
Graduate student(s): Narendranath Katakam
Post-doc(s): Randy Bradley
Research Experience for Undergraduates(s): Michael Fuller

Type of Institution:
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Partner Organizations:
Powertel: In-kind Support; Collaborative Research
Powertel engineers and managers provided material that was used in developing a multi-media case study.

Briggs & Stratton: In-kind Support; Facilities
The company provided data and materials to develop a case study.

Two lawyers: In-kind Support; Collaborative Research
Two lawyers provided information needed to develop the Lorn Textiles case study.

Crist Power Plant: In-kind Support
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: In-kind Support
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.

Superstar: Collaborative Research
We are working with this company to develop a case study that helps students prioritize among engineering R&D projects.

Larsen & Toubro Limited: In-kind Support; Facilities; Collaborative Research
Provided details on an international design problem faced when the company designed and built a polyvalent hall at Mauritius, an island in Africa. L&T is one of the largest construction companies in India.

Other collaborators:
(a) Faculty members at Nashville State Technical Institute worked with us to write articles that show 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 partnerships with 20 institutions represented by 22 faculty members. They have expressed a 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) We are working with the Indian Institute of Technology, Madras, to study issues that are faced by engineers who work on design projects as part of multinational teams.

(f) We conducted a LITEE workshop in Chile with cooperation from Dr. Letelier, Director for Research in Creativity and Higher Education, University of Santiago de Chile, Chile during September 2005.

Project Activities and Findings

**Project Goal(s):**

The goals of this project are:

(a) Develop new case studies that introduce engineering students to the complexity of real-world problems and how engineering companies work in the information age,

(b) Develop instructional materials to improve students' higher-level cognitive-based problem solving ability,

(c) develop multi-media/ web-based materials that show engineers working together physically and virtually to solve real-world problems,

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

(f) disseminate the materials by conducting workshops for engineering educators, creating a case emporium, and publishing in journals and conference proceedings.

**Updated Project Description:**

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 these synergies, the 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 (Portenberry, 2000).

In order to meet these needs, we have accomplished the following tasks related to the goals set for 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 work in the information age,

   Accomplishment: Developed Chick-fil-A case study to show the importance of operating systems in a fast-food business. An instructor's manual is currently being developed.

   Developed Powertel case study that discusses the design and construction of cell towers in response to higher market demand for wireless communication. An instructor's manual is currently being developed.

   Developed Lorn case study in order to showcase the importance of legal issues and the role of engineers as legal expert witnesses.
Developed a case study with Briggs & Stratton 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. Two case studies resulted from this project.

Developed a case study with Superstar corporation to show the process used in prioritizing among competing R&D projects.

Are developing a case study with Larsen & Toubro Limited, a leading construction company in India. This project was conducted by a multi-disciplinary team comprising faculty members and students from Auburn University and the Indian Institute of Technology Madras.

(b) Goal 2: develop instructional materials to improve students' higher-level cognitive-based problem solving ability,

These case studies have been implemented in computer science, engineering, and business programs at Harvard University, Texas Tech University, University of Detroit Mercy, University of Florida, Prairie View A&M University, University of Denver, Southern University, Auburn University, Louisiana State University, Troy State University, and Columbus State University. Evaluation results show the use of these materials improves the higher-level cognitive skills of students. The Crist case study has also been used to train powerplant personnel. The Spanish version of Della Power Plant case study was implemented in a workshop at Santiago, Chile.

(c) Goal 3: develop (on a pilot basis) a case emporium that will include a case study technical support repository and provide student teams with 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. An Instructor Support System has been developed that helps instructors from different institutions upload student presentations and work with each other.

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

A total of 20 workshops were held during this project to disseminate the materials to 420 faculty members. In addition, ten journal articles and eleven conference articles were published during this period.

The major findings of this project are: (a) Multimedia materials stimulate interest in engineering students in studying engineering topics, (b) female students become excited about engineering topics when multimedia instructional materials are used, (c) once convinced that the multimedia case studies are worthwhile, engineering faculty members find 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, (e) national organizations such as NAE see value in these materials and are willing to work with LITEE to disseminate them to larger groups of faculty members, and (f) there is a strong interest in other countries (such as Chile and India) for introduction of multi-media case studies.

Training and Development
STUDENTS:
During this period, the instructional materials have been used to train about 400 engineering students at Auburn University, Mercer University, IUPUI, and the Rose-Hulman Institute of Technology. About 300 business students at Auburn University and Southern University have also been trained with these materials. The Superstar case study was used in a statistics classroom.

The project also provided research experience and training to undergraduate, graduate, post-graduate students, and 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. Students from both engineering and business 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 received training in engineering, business, and information technologies. This training helped them go on to get excellent jobs in industries. More details are provided in the 'contributions to the principle discipline,' section.

FACULTY MEMBERS:
Faculty members from about 60 engineering schools have been trained in the use of these instructional materials at multiple conferences. In addition, interactive workshops have been 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 adoption of these materials in other schools.

Oct. 28, 2005, Bringing Together Theory and Practice in Engineering Classrooms: Regional Workshop, 1 day, Denver, CO, Engineering faculty members and administrators, 25 participants
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Feb. 17-18, 2005, Educating Engineers for the Information Age, 0.5 day, Washington, DC, NSF Principal Investigators, 35 participants

Total: 6 workshops, 182 participants
(a) Participated in the development and creation of the Business-Engineering-Technology Program at Auburn University.

(b) Organized a minitrack on IT in Education at the 2005 Americas Conference on Information Systems thereby informing MIS faculty members about the use of science and technology in businesses.

(c) Developed and delivered a program for minority Ph.D. students on 'Grant Writing Tips' in the area of educational research.

Innovations or Unique Successes to Date:

Principal Discipline of the Project: Innovation:
1. Innovation in content: The multimedia case studies provide students with an 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, audios, photos, and animation augment the students' ability to grasp complex engineering materials and make it easy to connect them to STEM theories. Students use multimedia technologies in their presentations (for example, to show a rotor or expert choice results in their presentation). It makes it possible to make decisions in a timely manner-an important feature
when we consider the limited time that is usually available to make decisions on problems that may involve millions of dollars. 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 to evaluate the effectiveness of the methodologies and have published many articles based on their work. We have extended this research by working with a faculty member from Psychology and are using print exposure tests.

5. Innovation in transferability: The case study materials have been adopted for use at Illinois Institute of Technology, the University of Virginia, and at Auburn University. The materials have also been used by the Colleges of Business at Auburn University and Louisiana State University. These show that the instructional materials can be used on different campuses to produce 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. A case study on ranking between various project priorities is currently being developed.

7. Innovation in Freshman Curriculum: Based on the materials developed in this project, Dr. Raju and Dr. Madsen have been teaching the 'Introduction to Engineering' course to freshman students starting Spring 2000. The materials have been used in this course every semester for approximately 70 students. Other instructors have also been using the textbook and methodology in teaching these students. A textbook is to be published by McGraw-Hill and will become available during 2007.

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 the 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 has shown that they are highly effective and result in students showing a stronger interest in the engineering subject-matter, as indicated by obtaining higher GPAs in subsequent semesters. The theories are explained using real-world connections to the case studies in every chapter of the textbook, so prescriptive theories are explained using descriptive real-world examples. This makes it possible for students to understand the connection between the theories and real-world issues.

(c) Simple engineering projects that could be performed in a course setting are described. The web site for the textbook (www.introtoengr.org) is being developed.
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 an appropriate mix of chapters, case study exercises, and project assignments when designing their lesson plans to meet the needs of their institutions and disciplines.

8. Innovation in Use of Case Studies in International Settings: We conducted a workshop at Santiago, Chile in order to investigate whether Spanish version of a case study will be considered useful by Spanish-speaking faculty members. The results of the study show that such an effort could motivate Hispanic-speaking students to become better motivated to pursue engineering education. We also developed a case study in collaboration with Indian Institute of Technology, Madras and Larsen & Toubro, Limited. This case study is planned to be used at IIT Madras.

Contribution to Other Disciplines of Science or Engineering: Recently one of our colleagues implemented one of the case studies in the engineering program at Harvard University. The case study was received well.

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 became operational in Fall 2001 and the first batch of students graduated in Spring 2003. The case studies produced with the help of NSF funding are very well received by the students in this program.

Development of Human Resources: This project has developed the skills of undergraduate students, graduate students, and post-doc fellows. It provided an opportunity to train 20 undergraduate students and through this project 16 masters students, five doctoral students, and two post-doc fellows were trained. These students state 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>
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<tbody>
<tr>
<td>Justin Cochran</td>
<td>A Cooling Tower Case Study; M.S.M.E., 2000</td>
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<tr>
<td>Vamsee Dasaka</td>
<td>Learning from Failure: The SRB Field Joint Redesign; M.S.M.E., 2000</td>
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<tr>
<td>Nadja Bleindung</td>
<td>Integration of IT into Manufacturing at Briggs &amp; Stratton, Inc.; M.S.M.E., 2002</td>
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<tr>
<td>Patrick Klesius</td>
<td>Operating Systems Decision at Chick-fil-A; MMIS, 2001</td>
<td></td>
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<tr>
<td>David Patton</td>
<td>Integrating AUCNET Case study in a Telecommunications Class; MMIS, 2002</td>
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<tr>
<td>Justin Williams</td>
<td>Powertel: Cell Site Construction Case Study; MMIS, 2001</td>
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<tr>
<td>Clay Hamblen</td>
<td>Implementing Della Case Study in a Physics Class; B.S. Honors, 2002</td>
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<tr>
<td>Andy Redman</td>
<td>Use of Virtual Teams to Collaborate on Analyzing</td>
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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
Xajiong Xue;  Information Technology Outsourcing and Virtual Teams;  Doctoral Paper Requirement, Spring 2003
Randy Bradley;  Assessing The Validity of Imposing GPA Entrance Requirements in Colleges of Business: An Empirical Investigation of the Impact of GPA on Higher-Order Cognitive Skills and Intrinsic Learning and Motivation;  Fall 2003
Srinivas Kumarasetti;  Prioritization of R&D Projects;  Fall 2004
Patrick Noll;  Prioritization of R&D Projects;  Fall 2004

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, the University of Pennsylvania, Shell, Louisiana State University, Troy State University, Alston and Bird, LLP., GE, and Anderson Consulting.

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 occupy office space 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 can take photos and incorporate them in their presentations.

In addition, the project has led to the 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, was created in 2000 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 STEM educators. It has now become an electronic journal and is available at www.jstem.org.
(b) Research has been performed to identify the factors that lead to the 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 allowing these information resources to not only help this project, but also other projects that work to 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 the case study method in engineering education is expected to fulfill many of the requirements of the ABET 2000 criteria.

Activities and findings:
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Research and Education Activities:

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Accomplishment: Developed Chick-fil-A case study to show the importance of operating systems in a fast-food business. An instructor's manual is currently being developed.

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(f) Goal 4: disseminate the material by conducting workshops for
engineering educators, create a case emporium, and publishing in journals and conference proceedings. A total of 20 workshops were held during this project to disseminate the materials to 420 faculty members. In addition, ten journal articles and eleven conference articles were published during this period.

Findings:

The major findings of this project are: (a) Multimedia materials stimulate interest in engineering students in studying engineering topics, (b) female students become excited about engineering topics when multimedia instructional materials are used, (c) once convinced that the multimedia case studies are worthwhile, engineering faculty members find 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, (e) national organizations such as NAE see value in these materials and are willing to work with LITEE to disseminate them to larger groups of faculty members, and (f) there is a strong interest in other countries (such as Chile and India) for introduction of multi-media case studies.

Training and Development:

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STUDENTS:

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FACULTY MEMBERS:

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Total: 6 workshops, 182 participants

Outreach Activities:

(a) Participated in the development and creation of the Business-Engineering-Technology Program at Auburn University.

(b) Organized a minitrack on IT in Education at the 2005 Americas Conference on Information Systems thereby informing MIS faculty members about the use of science and technology in businesses.

(c) Developed and delivered a program for minority Ph.D. students on 'Grant Writing Tips' in the area of educational research.

Curricular target(s) of Project

Discipline(s) Affected by Project:

Mechanical Engineering
Engineering
Business
Education

Subject(s) Affected by Project:

Introduction to Engineering
Linking IT to Real-world Engineering

Title(s) of Course(s) Affected by Project:

Introduction to engineering
Concepts of engineering design
Telecommunications management
Competitive strategies through information technologies
Introduction to MIS for MBA students
Database management
Advanced Physics for 11th and 12th graders
4-H camp on Energy Warriors

Summary Description of Pedagogical Approaches:

The introduction of multimedia in the case study method of instruction makes it very effective in achieving the goals. The pedagogy consists of teaching theories first, then providing students with an opportunity to read about how the theories were used to solve a real-world problem, and then applying the skills they have learned to analyze another real-world problem.
Journal Publications:


Book(s) of other one-time publication(s):


Types of products (e.g. textbooks, lab manuals, articles, CD-ROMs, etc.):


Other Types of Products:

The Journal of SMET (STEM) Education: Innovations and Research has been developed by LITEE to publish case studies and articles that pertain to engineering education on a bi-annual basis.

Other Specific Products:

Physical collection (samples, etc.)

The books are published by Tavenner Publishers and available for use by students.

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

Data or databases

www.jstem.org

The Journal of STEM Education: Innovations and Research has been developed by LITEE to publish case studies and articles that pertain to engineering educational on a bi-annual basis.

The journal has good acceptance among academics and there is a steady stream of papers being submitted to this journal. A special issue focusing on the STEM education of pre K-12 students is expected to be published during Dec. 2004

Internet Dissemination

Internet Dissemination:

www.introtoengr.org www.auburn.edu/research/litee

This site provides information about the Laboratory for Innovative Technology and Engineering Education (LITEE) at Auburn University.

Additional Information

Description of Equipment or Instrumentation:

(1) Computers for use in the LITEE lab
(2) 2 Plasma Monitors so researchers can work collaboratively
(3) Digital cameras to encourage students to take photos of technical and engineering equipment
(4) A mobile cart and notebook PCs for use by students
(5) 2 high speed color printers so color can be used to enhance presentations and brochures
Contributions:

Contributions within Discipline:

Principal Discipline of the Project:

Innovation:
1. Innovation in content: The multimedia case studies provide students with an 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, audios, photos, and animation augment the students' ability to grasp complex engineering materials and make it easy to connect them to STEM theories. Students use multimedia technologies in their presentations (for example, to show a rotor or expert choice results in their presentation). It makes it possible to make decisions in a timely manner—an important feature when we consider the limited time that is usually available to make decisions on problems that may involve millions of dollars. 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 to evaluate the effectiveness of the methodologies and have published many articles based on their work. We have extended this research by working with a faculty member from Psychology and are using print exposure tests.
5. Innovation in transferability: The case study materials have been adopted for use at Illinois Institute of Technology, the University of Virginia, and at Auburn University. The materials have also been used by the Colleges of Business at Auburn University and Louisiana State University. These show that the instructional materials can be used on different campuses to produce 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. A case study on ranking between various project priorities is currently being developed.
7. Innovation in Freshman Curriculum: Based on the materials developed in this project, Dr. Raju and Dr. Madsen have been teaching the 'Introduction to Engineering' course to freshman students starting Spring 2000. The materials have been used in this course every semester for approximately 70 students. Other instructors have also been using the textbook and methodology in teaching these students. A textbook is to be published by McGraw-Hill and will become available during 2007.

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 the 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 has shown that they are highly effective and result in students showing a stronger interest in the engineering subject-matter, as indicated by obtaining higher GPAs in subsequent semesters. The theories are explained using real-world connections to the case studies in every chapter of the textbook, so prescriptive theories are explained using descriptive real-world examples. This makes it possible for students to understand the connection between the theories and real-world issues.

(c) Simple engineering projects that could be performed in a course setting are described. The web site for the textbook (www.introtogrn.org) is being developed.

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 an appropriate mix of chapters, case study exercises, and project assignments when designing their lesson plans to meet the needs of their institutions and disciplines.

8. Innovation in Use of Case Studies in International Settings: We conducted a workshop at Santiago, Chile in order to investigate whether Spanish version of a case study will be considered useful by Spanish-speaking faculty members. The results of the study show that such an effort could motivate Hispanic-speaking students to become better motivated to pursue engineering education. We also developed a case study in collaboration with Indian Institute of Technology, Madras and Larsen & Toubro, Limited. This case study is planned to be used at IIT Madras.

Contributions to Other Disciplines:

Contribution to Other Disciplines of Science or Engineering:
Recently one of our colleagues implemented one of the case studies in the engineering program at Harvard University. The case study was received well.

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 became operational in Fall 2001 and the first batch of students graduated in Spring 2003. The case studies produced with the help of NSF funding are very well received by the students in this program.
Contributions to Education and Human Resources:

Development of Human Resources:
This project has developed the skills of undergraduate students, graduate students, and post-doc fellows. It provided an opportunity to train 20 undergraduate students and through this project 16 masters students, five doctoral students, and two post-doc fellows were trained. These students state 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>
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<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>Integration of IT into Manufacturing at Briggs &amp; Stratton, Inc.</td>
<td>M.S.M.E., 2002</td>
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<tr>
<td>Patrick Klesius</td>
<td>Operating Systems Decision at Chick-fil-A</td>
<td>MMIS, 2001</td>
</tr>
<tr>
<td>David Patton</td>
<td>Integrating AUCNET Case study in a Telecommunications Class</td>
<td>MMIS, 2002</td>
</tr>
<tr>
<td>Justin Williams</td>
<td>Powertel: Cell Site Construction Case Study</td>
<td>MMIS, 2002</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 Teams; Doctoral Paper Requirement, Spring 2003</td>
<td></td>
</tr>
<tr>
<td>Srinivas Kumarasetti</td>
<td>Prioritization of R&amp;D Projects</td>
<td>Fall 2004</td>
</tr>
<tr>
<td>Patrick Noll</td>
<td>Prioritization of R&amp;D Projects</td>
<td>Fall 2004</td>
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</tbody>
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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, the University of Pennsylvania, Shell, Louisiana State University, Troy State University, Alston and Bird, LLP., 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 occupy office space 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 can take photos and incorporate them in their presentations.

In addition, the project has led to the 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, was created in 2000 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 STEM educators. It has now become an electronic journal and is available at www.jstem.org.

(b) Research has been performed to identify the factors that lead to the 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 allowing these information resources to not only help this project, but also other projects that work to 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 the case study method in engineering education is expected to fulfill many of the requirements of the ABET 2000 criteria.

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, Southern University and Louisiana State University (LSU). The researchers at Southern University have integrated some of these case studies in the Introduction to MIS course in the MBA program, thereby educating non-technical students about the relevance and importance of engineering and technical disciplines.

Special Requirements for Annual Project Report:

Categories for which nothing is reported:
Special Reporting Requirements
Animal, Human Subjects, Biohazards

Contact Information for Project: Collaborating Awards
Project Activities and Findings: Other Features of Project
Internet Dissemination: FTP Server Address
Internet Dissemination: Gopher Server Address
Additional Information: Additional Sources of Funding

We welcome comments on this system.