Impact of an Engineering Case Study in a High School Pre-Engineering Course

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Abstract

Students at an all-girls high school who were enrolled in an introduction to engineering course were presented an engineering case study to determine if the case study affected their attitudes toward engineering and their abilities to solve engineering problems. A case study on power plants was implemented during a unit on electrical engineering. Pre- and post-surveys were administered to evaluate changes in attitude, perceptions, and abilities. Students were provided a tour of a power plant, performed individual and group research, and worked in teams to develop a solution to a problem faced at a power plant. The groups made presentations defending their choices and provided written reports. These students showed improvement in development of cognitive skills as a result of the case study. Students also reported improvements in their attitudes toward engineering and small gains in team working skills. The case study provided a realistic example of the practice of engineering and enabled students to make informed choices regarding their continuation in the study of engineering and technology programs in college. High school students demonstrated an appreciation for this method of learning and indicated that the approach was beneficial in understanding the subject matter and developing teamwork, problem solving and communication skills.

Keywords: project-based learning, engineering, case study

Introduction

In collaboration with Mount Notre Dame High School (MND) and several other Cincinnati-area schools, the University of Cincinnati developed a pre-engineering course for high school students. The goal of the course is that students will have a good understanding of the practice of engineering and will be able to make an informed choice regarding pursuing engineering or technology programs in college. The course "Engineering Your Future" was taught for the first time in the 2007 – 2008 academic year at four schools. In the 2008 – 2009 school year, seven schools offered a version of the course to their students.

MND is a four-year comprehensive, college preparatory Catholic girl's high school located in Reading, Ohio, a suburb of Cincinnati. The student body is approximately 750 young women. Over 97% of recent graduates have pursued post-secondary education. The course is open to juniors and seniors interested in learning more about the field of engineering who have completed Algebra II and have an 85 average in their science courses at Mt Notre Dame. In the 2007 – 2008 school year, 13 of the 23 students in the course went on to study engineering. In the 2008 – 2009 academic year, 17 seniors were enrolled in the course.

Through the development and implementation of the course content, activities, and pedagogies, the collaborators adopted the constructivist perspectives of Jean Piaget and Lev Vygotsky. Specifically, we emphasized the active role the students play in constructing meaning and knowledge based on experiences and opportunities to test hypotheses as members of a group. To this end the course [1]:

- Provided opportunities for a variety of activities for learning
- Introduced new concepts after students had experiences with the concept
- Encouraged student-to-student interaction (development of socialization and team building skills)
- Allowed students to work on open-ended problems to develop the critical skills necessary for them to succeed in the 21st century workforce

The pre-engineering course was developed by the collaborators after extensive review of existing curricula and resources [2]. The collaborators created a project-based course to promote active learning and development of problem-solving and teamwork skills. Teaching material and a number of projects were provided by the text Engineering Your Future: A Project-Based Approach [3]. A significant number of projects were also used from other publically available sources, notably Teach Engineering [4], Try Engineering [5], A World in Motion [6] and Project STEP [7].

While the textbook provided a good resource for the students, the majority of the instructional materials were provided in the form of web-based modules. A module is a 10 to 15 minute presentation featuring audio, video and PowerPoint that is provided through streaming. Figure 1 illustrates the format of the instructional modules. Instructional modules covered the various engineering disciplines, the engineering design process, teamwork, communication, and a number of project-specific topics.

The course was taught in units with different disciplines of engineering or engineering skills used as a focus of that unit. The structure and format of the instructional modules, providing content in manageable units, in conjunction with the projects helped students connect academic standards to the practice of engineering [8]. Rutz et al. [9] provide additional detail on the initial implementation of the course.

The program collaborators felt that a case study would fit the constructivist pedagogy implemented in the course and could provide a method of student engagement and learning that would complement and augment the other content and activities.

Study Context

The National Science Board reports that failure of the nation to meet STEM education needs has serious, negative implications for the US workforce [10]. The NSB report enumerates a call to action that has local implications. Particularly, a collaboration of schools and col-

leges can "improve the linkages between high school, higher education and the workforce" and help to prepare teachers to teach STEM content effectively.

The Business – Higher Education Forum [11] calls attention to a widening gap between the skills required of the workforce and the education received by many individuals. In "Building a Nation of Learners," they call for actions that will close this gap and create a "nation of learners" proficient in lifelong learning. The report specifically calls for creating content that is relevant and challenging, encouraging learning through interaction, and increasing access to appropriate content.

In "Are They Really Ready to Work?" the Conference Board [12] claims that the emerging workforce is unprepared to make the contributions society requires. The report describes both basic knowledge and applied skills as necessary for the workforce, with applied skills being particularly wanting in the emerging workforce. Among the skills that are lacking are teamwork, critical thinking, problem solving and communication.

The projects used in the course provide a good framework for understanding the nature of the practice of engineering and have been successful at developing problem-solving, leadership and teamwork skills in students. However, the projects do not provide actual situations faced by engineers in the workforce. The inclusion of a case study was seen as a potentially meaningful addition which could provide students a more realistic understanding of the nature of the engineering profession.

Research Model and Hypotheses

Julayn and Duckworth [13] describe the need to provide a learning environment that promotes a greater understanding of the physical world. They suggest that a course requires investigation of each student's ideas, the articulation of those ideas and the accommodation of the ideas of other students. Crawford [14] describes this approach in mathematics and illustrates that concepts are learned in context of the setting, not as abstract, stand-alone ideas.

The collaborators sought to incorporate content and activities that promoted the learning described by Crawford, Julayne and Duckworth. An engineering case study was deemed an appropriate and relevant mechanism to improve the effectiveness of the course.

Through this study we sought to answer these research questions relative to female high school students:

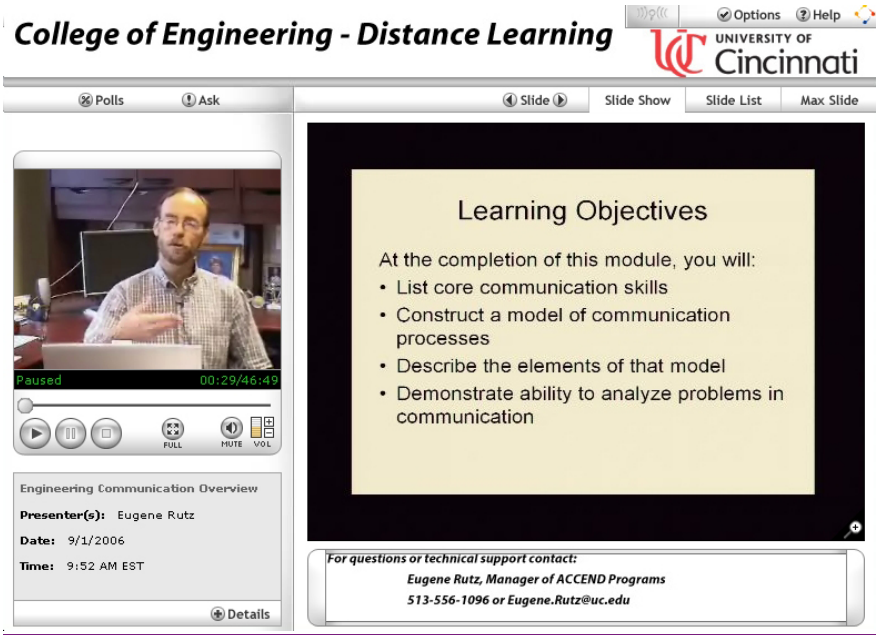

Figure 1. Instructional module

1. Does the use of a case study improve the attitude of these students to the study of engineering?
2. Does the use of a case study change this population's understanding of the relevance of engineering careers?
3. Does the use of a case study promote higher-order learning in this student population?
4. Does the use of a case study improve this population's team working skills?
5. Does the use of a case study have an impact on communication skills?
6. Does the use of a case study help this population understand the nature of engineering professions?

Methodology

The case study chosen was the Della Steam Plant case provided by the Laboratory for Innovative Technology and Engineering Education [15]. The case study was selected since it complemented the existing course material well, it provided a learning experience that was not part of the existing course material, and there were local resources that could facilitate this particular case. In addition, other educators have used the case study and reported on the results of its use [16, 17]

The case study was implemented as part of the unit on electrical engineering. The students were introduced to the study with a field trip to the University of Cincinnati power plant. During the tour, the students were able to see

the workings of an operating power plant and ask questions of the plant manager. After the tour, the students were introduced to the case study online. They read the problem statement and did some basic research on power plants. Next, the students watched an instructional video module regarding power plants and a classroom presentation was made by a practicing engineer who had experience in the power generation industry.

The students then began the work on the case study. In this case study students were divided into four distinct groups. Two of the groups assumed the roles of engineers at the plant who had different recommendations regarding an issue faced by the plant. A third group served as a jury which mimicked the role of the plant manager who would judge between the recommendations. The fourth group was given the assignment at looking at future technologies and how these could be implemented for this industry.

As part of the case study, each group was required to:

I. Analyze the case study using the materials provided. This included:

- Reading written materials
- Analyze the materials as part of a specific team
- Identifying and using outside reference material
- Preparing presentations

II. As a member of a specific team debate the competing recommendations as follows:

- Team 1: defend alternative 1
- Team 2: defend alternative 2
- Jury Team: decide between the two recommendations.
- Future Technologies Team: Propose new technologies.

III. Submit a written report to the instructor.

Each team was composed of four individuals. The jury team was made up of two students and two current engineers. The remaining teams were comprised of four students in the pre-engineering course.

A pre-survey and post-survey were administered using an online application to measure the impact of the case study methodology on this group of students. The survey questions are provided on the LITEE website [18] and are included in the Results section. These instruments were used to be consistent with other educators who have implemented the LITEE case studies in order to contribute to a body of evidence regarding these case studies.

Results

The results of the pre- and post survey are given in Tables 1-5 to correlate to research questions 1 – 5 posed earlier. Table 6 provides common student responses to several of the open-ended questions from the surveys regarding student engagement, learning and use of case studies. Table 7 provides common responses to a different survey used to evaluate research question 6 which asked students "What do engineers do?"

Discussion

The case-study was implemented in a course

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Engineering is a subject learned quickly by most people	Pre	6.3%	43.8%	43.8%	6.1%	0.0%
	Post	12.1%	48.5%	30.3%	10 %	0.0%
Engineering concepts are easy to understand	Pre	0.0%	25.0%	12.5%	50.0%	12.5%
	Post	0.0%	21.2%	15.2%	51.5%	12.1%
I understand how to apply analytical reasoning to Engineering	Pre	0.0%	0.0%	6.7%	93.3%	0.0%
	Post	0.0%	6.3%	28.1%	53.1%	12.5%
Engineering is highly technical.	Pre	0.0%	6.7%	26.7%	53.3%	13.3%
	Post	0.0%	6.3%	28.1%	53.1%	12.5%
I can learn Engineering	Pre	0.0%	0.0%	0.0%	93.3%	6.7%
	Post	0.0%	0.0%	0.0%	83.9%	16.1%
I expect using the instructional materials will improve my attitude toward Engineering	Pre	0.0%	0.0%	13.3%	74.9%	11.8%
	Post	0.0%	0.0%	9.4%	84.4%	6.2%

Table 1. Use of a Case Study Improves the Attitude of Students to the Study of Engineering

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Engineering is irrelevant to my life	Pre	60.0%	33.3%	6.7%	0.0%	0.0%
	Post	59.4%	37.5%	3.1%	0.0%	0.0%
Engineering skills will make me more employable	Pre	0.0%	0.0%	31.3%	31.3%	37.4%
	Post	0.0%	0.0%	21.2%	45.5%	33.3%
If I ever were to become a high ranking engineer in a company I would hire other engineers to help with decision making.	Pre	0.0%	0.0%	0.0%	66.7%	33.3%
	Post	0.0%	0.0%	3.1%	62.5%	34.4%
I believe that an interdisciplinary focus is important in Engineering	Pre	0.0%	5.9%	35.3%	47.1%	11.7%
	Post	0.0%	2.9%	26.5%	58.8%	11.8%

Table 2. Use of a Case Study Changes This Population's Understanding of the Relevance of Engineering Careers

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I expect to learn how to identify engineering tools that will assist me in decision-making using the instructional materials	Pre	0.0%	7.1%	28.6%	64.3%	0.0%
	Post	0.0%	3.3%	16.7%	73.3%	6.7%
I expect to learn how to interrelate important topics and ideas using the instructional materials	Pre	0.0%	0.0%	13.3%	86.7%	0.0%
	Post	0.0%	0.0%	6.3%	84.4%	9.3%
I expect to learn how to identify various alternatives/solutions to a problem using the instructional materials	Pre	0.0%	0.0%	6.7%	93.3%	0.0%
	Post	0.0%	0.0%	3.1%	87.5%	9.4%
I expect to improve my problem solving skills using the instructional materials.	Pre	0.0%	0.0%	6.7%	80.0%	13.3%
	Post	0.0%	0.0%	3.1%	81.3%	15.6%
I expect to learn how to sort relevant from irrelevant facts using the instructional materials.	Pre	0.0%	0.0%	14.3%	78.6%	7.1%
	Post	0.0%	0.0%	6.5%	83.9%	9.6%
I expect my confidence in applying Engineering concepts to real situations to improve as a result of this Engineering course	Pre	0.0%	0.0%	13.3%	60%	26.7%
	Post	0.0%	0.0%	9.4%	71.9%	18.7%

Table 3. Use of a Case Study Promotes Higher-Order Learning in this Student Population

that was by design very hands-on and which required the students to work in teams, solve problems and make presentations. The use of a case-study introduced another approach that had greater connections to the actual practice of engineering than the other projects and activities in the course.

The data in the pre- and post-surveys were used to evaluate the research questions. Because of the small sample size (n=17) statistical analyses were not performed. Presenting the data in tabular form was deemed to be instructive while not presenting potentially misleading results. In addition, because of the nature of the course it was not possible to control many factors that would provide for a more quantitative analysis. For example, it was not possible to have a control group and an experimental group and students who participate in the course do not represent a random sample of high school students. Moreover, this was only the second year for this course and some curricular changes were made after the first year based on course and student assessment.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I expect using the instructional materials will help me improve my team-building and interpersonal skills	Pre	0.0%	0.0%	6.7%	60.0%	33.3%
	Post	0.0%	0.0%	3.1%	68.8%	28.1%
I expect using the instructional materials will help me and my classmates listen carefully to each other's statements and ideas	Pre	0.0%	0.0%	6.6%	66.7%	26.7%
	Post	0.0%	0.0%	3.1%	75.0%	21.9%
I expect using the instructional materials will help me and my classmates arrive at decisions based on consensus building	Pre	0.0%	0.0%	13.4%	73.3%	13.3%
	Post	0.0%	0.0%	6.3%	78.1%	15.6%
I expect using the instructional materials will help me and my classmates share ideas with each other	Pre	0.0%	0.0%	0.0%	86.7%	13.3%
	Post	0.0%	0.0%	3.1%	81.3%	15.6%
I expect using the instructional materials will enhance my interactions with my classmates	Pre	0.0%	0.0%	6.7%	73.3%	20.0%
	Post	0.0%	0.0%	6.3%	78.1%	15.6%

Table 4. Use of a Case Study has an Impact on Team Working Skills

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I expect my writing skills to improve as a result of this Engineering course	Pre	0.0%	18.7%	37.5%	43.8%	0.0%
	Post	0.0%	9.1%	27.3%	54.5%	9.1%
I expect my presentation skills to improve as a result of this Engineering course	Pre	0.0%	0.0%	13.3%	74.2%	12.5%
	Post	0.0%	0.0%	6.3%	75.0%	18.7%
I expect my informal communication skills to improve as a result of this Engineering course	Pre	0.0%	0.0%	23.5%	52.9%	23.6%
	Post	0.0%	0.0%	14.7%	64.7%	20.6%

Table 5. Use of a Case Study Has An Impact On Communication Skills

A qualitative assessment of each study question is presented below.

Research Question 1 - Does the use of a case study improve the attitude of these students to the study of engineering?

The data provided in Table 1 indicates that the case study did affect the attitude of the students regarding the study of engineering. The responses to "Engineering is a subject learned quickly by most people" and "I understand how to apply analytical reasoning to engineering" indicate that the students are more realistic in their expectations after the case study than prior to the case study. In particular the case study seemed effective at helping students appreciate the complexity of making proper engineering decisions. Other measures of attitude were not significantly affected by the case study though it was encouraging to note that 100% of the students indicated they agreed or agreed strongly with the statement "I can learn engineering."

Research Question 2 - Does the use of a case study change this population's understanding of the relevance of engineering careers?

The data provided in Table 2 indicates that there was no significant change in the students' understanding of the relevance of engineering

QUESTION	PRE SURVEY	POST SURVEY
What teaching styles do you find most helpful in learning new material? (for example, lecture, distance learning, power point presentations, multi-media case studies, group projects, etc.)	Most students said group projects, power point presentations and hands on experiences	Students provided the same responses except three added multi-media case studies
What learning styles (for example, independent working, team working, task oriented, intuitive, objective, sensitive) do you believe should be addressed to help you learn new material?	Team work was the most recorded answer	Team work was the most recorded answer
Do you prefer to work alone or in groups to solve problems?	In groups	In groups
How beneficial would you rate the use of multi-media case studies in your learning the material presented in this course?	N/A	Every student described the case study as helpful, beneficial or very beneficial. Responses referred to problem solving and application of principles to actual situations as reasons.
How helpful did you find the use of student groups/teams to solving the problems presented in the case studies?	N/A	Every student described the use of teams as helpful for solving the problems. A common theme was "better solutions to problems were developed based on the diversity of ideas"

Table 6. Common Student Response to Select Questions from LITEE Surveys

based on the use of a case study. Pre- and post-survey data showed little change for most items. However, the case study was effective at helping students better understand that an interdisciplinary focus is important in engineering.

Research Question 3 - Does the use of a case study promote higher-order learning in this student population?

The data provided in Table 3 indicates that the case study was effective at helping students identify proper engineering solutions and solve open-ended problems. While the gains were modest, there were gains in each category relative to this research question including identifying engineering tools, interrelating important topics, identifying alternative solutions, improving problem solving skills and applying engineering concepts. The case study was particularly effective at helping students discern that engineering decisions are based on information but not all the information is relevant in solving the problem at hand. Responses in Table 6 also indicated that the case study was beneficial in developing problem solving approaches.

Research Question 4 - Does the use of a case study improve this population's team working skills?

The data provided in Table 4 indicates that the case study had a very small positive affect in improving the students' team working skills. Student responses indicate they had a significant appreciation for the importance of teamwork skills prior to implementing the case study. The greatest improvement was in the area of helping students arrive at decisions based on consensus building. Responses provided in Table 6 indicate that students strongly prefer learning in a team setting.

Research Question 5 - Does the use of a case study have an impact on communication skills?

The data provided in Table 5 indicates that the students perceived that they had significant gains in their communication skills. This was particularly true for writing skills where there

Pre-course Survey
They design/build things.
I think that engineers solve everyday problems. They also try to think of ways to make life easier whether that would be with machines or technology.
Build things that are really cool!
They try to solve and find ways to make things and complete certain task.
I think that engineers solve and work on different types of projects and think outside the box.
Engineers are scientists who use their studies to advance the technology that the world already has.
Help make our society a better place by having an understanding of different types of technology.
Engineers work on projects and solve problems in the real world. They look at different things is new ways.
They build things and make things like a building, or plane.
They use math and science skills to create new ideas to better the economy.
Engineers make things and fix things.
They create new technology with the help of math and science.
They use math and science to create different types of products.
I think that engineers work to solve problems in society and look for solutions to making life better.
They fix things.
There are many different kinds of engineers so it's hard to say.
Think outside the box, create or help the process of how to make products better or actually create new products/ideas.
Engineers, depending on you field, take a problem a solve it using math and science. They also ask questions to which they see if they can answer them.
Post-course Survey
Engineers are people who apply the science and math to everyday life properties.
Engineers work on all different products and solve everyday problems. They work together to make the world a better place
Engineers work to efficiently solve problems present in today's society.
Engineers develop and design products and work together as a team
They help make and design different ways to help make the human life easier.
Engineers make and invent stuff for the greater good of society.
They work with fellow engineers to solve a problem in a concise way and to develop new ideas on how to make things more functional.
Engineers do almost everything. They work with all different kinds of people and in all different fields, so there is no real definition of what engineers do.
They work together to solve problems and come up with new ways to do things. They research and test in their fields
Engineers work to improve and create products to help improve the environment.
Help design new things that make the lives of others easier
Engineers can deal with the designing or producing of just about anything.
They collaborate on projects to make more efficient products.
Engineers design things for companies, fix things, and figure out solutions to problems.
Engineers do all kinds of things. They design, develop, build, plan, research, and manufacture almost everything that we come in contact with each day.

Table 7. Response to "What Do Engineers Do?"

was 20% increase in the number of students who expected this skill to improve as a result of the course.

Research Question 6 - Does the use of a case study help this population understand the nature of engineering professions?

The data provided in Table 7 conclusively shows that the course and the case study improved students' understanding of aspects of the engineering profession. In the pre-course

survey, no student indicated that engineers collaborated or worked on teams while in the post-course survey, 6 of the 15 responses included collaboration or team work. The post-course responses also indicate an improved level of sophistication and completeness in students' understanding of the nature of the engineering profession.

As stated in the in the introduction, the goal of the pre-engineering course is to equip students to make an informed decision regarding studying engineering / technology in college. To this end, projects and experiences are provided so that students learn about the practice of engineering and can make a realistic choice regarding a program of study. Several items from Table 1 indicate that the case study was effective at achieving this overall course goal. Specifically, the responses to "Engineering is a subject learned quickly by most people," "Engineering skills will make me more employable," and "I expect using the instructional materials will improve my attitude toward Engineering" indicate that students are less neutral on these topics and are better informed.

This study was implemented in a course of female high school students who had self-selected into the pre-engineering course. Since this is not a random selection of students and the number of students is small, others should be careful in extrapolating results from this population to a more general population.

Conclusions

The case study methodology has been shown to be effective at developing higher order cognitive skills such as critical thinking, problem solving, and integrating information from multiple sources [19, 20]. The pre-engineering course "Engineering Your Future" was purposefully designed to focus on hands-on activities, problem-solving and teamwork. Project work, written and oral communication and the use of instructional technology are all significant factors in the course. Because of the design of the course, students were able to begin to develop similar higher order cognitive skills even before the inclusion of the case study. While the study had certain limitations (small size, no control) it is the authors' opinions that the gains in student attitudes and higher-order learning would have been much more pronounced in a more traditional course that did not already incorporate many of these problem-based learning elements.

The case study did introduce a number of concepts that had not been a part of the course or amplified these significantly. These included:

- The complexity of engineering analysis and decision making
- The potential scope and impact of a seemingly simple decision
- The negotiation required when alternative solutions are proposed
- The breadth and depth of analysis required to arrive at an appropriate solution

Female high school students reported improvement in development of cognitive skills as a result of implementing a case study as part of the curriculum. These students also had improvements in their attitudes toward engineering because of the case study and associated activities. Moreover, the case study provided the most realistic presentation of the practice of engineering thus enabling these students to make informed choices regarding their continuation in the study of engineering and technology.

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References

1 R. Martin, C. Sexton, T. Franklin and J. Gerlovich. Teaching Science for All Children: Inquiry Methods for Constructing Understanding 3rd edition. Pearson Education. (2005).

2 E. Rutz, The Cincinnati STEM Initiative, Proceedings of the ASEE Annual Conference. June 24-27, 2007. Honolulu, HI (2007).

3 A. Gomez, W. Oakes, and L. Leone. Engineering Your Future: A Project-Based Introduction to Engineering. Great Lakes Press. St. Louis, MO. (2006).

4 Teach Engineering. Available at www.teachengineering.org. Hosted by the National Science Digital Library. (2007).

5 Try Engineering. Lesson Plans available at www.tryengineering.org/lesson.php (2007).

6 SAE International. A World in Motion. www.awim.org. (2007)

7 University of Cincinnati. Project STEP. http://www.eng.uc.edu/step (2007).

8 J. D. Forbes, C. R. Saunders, How We Reinvented the High School Experience. Educational Leadership, Vol. 65 Issue 8, p42-46. (2008).

9 E. Rutz, B. Lien, M. Shaffer, and S. Brickner. Accessible STEM Education. *Proceedings of the ASEE Annual Conference*. Pittsburgh, PA. (2008).

10 National Science Board. A National Action Plan for Addressing the Critical Needs of the US Science, Technology, Engineering and Mathematics Education System. p. 2. National Science Foundation. Arlington, VA. (2007).

11 Business – Higher Education Forum. Building a Nation of Learners. Available at www.bhef.com/publications/2003_build_nation.pdf (2003).

12 J. Casner-Lotto, and L. Barrington. Are They Really Ready to Work? The Conference Board, Partnership for 21st Century Skills, Corporate Voices for Working Families, and Society for Human Resource Management. Available at www.conference-board.org/publications/describe.cfm?id=1218 (2006).

13 C. Julayne and E. Duckworth. A Constructivist Perspective on Teaching and Learning Science. In Constructivism – Theory, Perspectives and Practice 2nd Edition. C. Fosnot, editor. Teachers College Press. New York, NY. (2005).

14 K. Crawford. Vygotskian Approaches To Human Development In The Information Era. *Educational Studies in Mathematics.* Vol. 31, pgs. 43-62. (1996).

15 LITEE. Auburn University. www.litee.org/site. (2009).

16. K. Mohan. Case Study Reveals Several Benefits Including Development Of Soft Skills For Engineering Technology Students And Assessment Of Key Tac-Abet Program Outcomes. *Proceedings of the ASEE Annual Conference*. Chicago, IL (2006).

17. S. Das. Implementing A Multi-Media Case Study In a Traditional Laboratory Class. *Proceedings of the ASEE Annual Conference*. Chicago, IL (2006).

18. LITEE. Curriculum Assessment Tools. http://www.litee.org/site/index.php?option=com_content&view=article&id=77&Itemid=88 Auburn University. (2009)

19 C. S. Sankar, V. Varma, P. K. Raju. Use of Case Studies in Engineering Education : Assessment of Changes in Cognitive Skills. Journal of Professional Issues in Engineering Education and Practice. ASCE. p. 287-296. (2008).

20 A. Mehta, H. Clayton, and C. S. Sankar. Impact of Multi-media Case Studies on Improving Intrinsic Learning Motivation of Students. J. Educational Technology Systems, vol. 36(1) p. 79-103. (2007)

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