Developing Leadership Skills in *Introduction to Engineering Courses* through Multi-Media Case Studies

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Abstract

A literature review identifies a partial list of leadership skills to include developing higher-order cognitive skills, team working skills, positive attitude, and ability to transfer these skills to future environment. This paper discusses the results of research conducted on the use of multiple instructional methodologies in two different Introduction to Engineering classes in order to develop some of the leadership skills. The instructional methodologies used in these courses were lectures, PowerPoint slides and visuals, case studies, quizzes, small group discussions, and projects. The research question addressed in this paper is: Which instructional methodologies enhance students' mastery of the skills and possession of the attributes that are increasingly required of engineering graduates? A questionnaire was developed to obtain responses from students. The use of projects and multi-media case studies was perceived as valuable in enhancing the learning experiences and attitude toward engineering. The students valued these experiences because they brought theories and real-world practices together and provided an opportunity for them to work together. In both sections, students believed that they had better problem-solving skills and a better foundation of basic skills as a result of having taken the course.

Introduction

Learning can be characterized as changing one's way of experiencing some phenomenon, and teaching is then creating situations where such change is fostered. (Booth, 2004, Bransford et al., 2000). In any subject, there is important content – phenomena, concepts, theories, principles, skills – and there are particularly productive ways of understanding these, which form the backbone of the subject (Meyer and Land, 2003). University students are learning through interaction with current knowledge to equip them with the skills they will need once they graduate and enter the workforce to deal with situations that may occur many years later in professional, personal, and social contexts that can't be specified in advance (Bowden and Marton, 1998). In essence, university students are engaged in learning for an unknown future and instructors must design the curriculum with that in mind. Rosalind Williams (2002, 2003) argued, "The mission of engineering changes when its dominant problems no longer involve the conquest of nature but the creation and management of a self-made habitat." She went on to depict engineering education as an area that needs to provide an environment where students learn to justify and explain their approach to solving problems and also to deal with people who have other ways of defining and solving problems. In a recent survey, more than half of the 500 school and district academic leaders stated that their top educational technology priority for the new administration and Congress should be assessing students' 21st-century skills, such as problem solving, critical thinking, creativity, communication, and collaboration (e-School News, 2008).

In discussing distributed leadership, Gorton and Alston (2009) emphasize the importance of determining the level of involvement a leader should undertake to bring about strategic change; how the leader chooses to accomplish the core mission of the organization requires "a deeper understanding and discussion of people, potential, and results" (p. 16). Leaders need to be able to work with others to ensure that the work and functions of the organization are coordinated without the need for creating new teams or requiring more meetings, characteristics that require the ability to work interdependently. They also discuss the fact that, to be a good leader, one must develop good group dynamics skills to match people with tasks that fit their knowledge and skills. Another aspect of leadership they suggest is that group members must have a spirit of cooperation and teamwork, they must feel valued, they must share goals, and they must develop a sense of cohesiveness and trust to achieve the group goals. Ethical decision making is also an integral part of leadership; case studies teach students to be sensitive to potential ethical dilemmas that occur in organizations and give them opportunities to practice the process of considering all options that may influence their decisions (Gorton & Alston, 2009). Fullan (2001) asserts that organizations must become learning organizations to be successful; this involves learning how to think critically to maintain the learning needed to endure rapid change.

Nair et al., (2009) state that university graduates do not possess important skills required by employers, such as communication, decision-making, problem-solving, leadership, emotional intelligence, social ethics skills as well the ability to work with people of different backgrounds. Engineering graduates perceived that they were not well prepared for working in multi-disciplinary teams, leadership, practical preparation, and management skills (Martin et al., 2005). Leadership is defined as influencing, guiding in direction, course, action, and opinion (Bennis and Nanus, 1985). Daniels (2009) insists that we need to develop individuals who will lead our organizations in the future. Farr et al., (1997) list that nine broad and domain independent qualities of big thinker, ethical and courageous, masters change, risk taker, mission that matters, decision maker, uses power wisely, team builder, and good communicator comprise the skills needed of a leader. The competing value framework (Zafft et al., 2009) lists that a leader has to be engaged in a wide range of behaviors including relating to people, leading change, managing processes, and producing results.

Some of the common skill sets mentioned in these articles include developing higher-order cognitive skills, team working skills, positive attitude, and ability to transfer these skills to work environments. Instructional methodologies, such as lectures, PowerPoint slides and visuals, case studies, quizzes, small group discussions, and projects, are available to develop these skills in engineering students. Falkenburg stressed the need for new instructional methodologies in order to use information technologies more effectively in engineering classrooms (Falkenburg, 2004, Arreola et al., 2003). The National Academy of Engineering (2004) recommends the development of case studies based on both engineering successes and failures and the appropriate use of a case-studies approach in undergraduate and graduate curricula. Multi-media case studies can be a powerful tool in exploring the nature of the world around us, including its technological systems (Backer, 2005). Projects have been a well-established method to provide hands-on training to students in engineering (Nikolic, 2002).

This paper focuses on studying multiple instructional methodologies and investigates which ones develop some of the leadership skills in an introductory engineering class. Thus, we pose the following research question for this paper: Which instructional methodologies enhance students' mastery of some of the leadership skills and possession of the attributes that are increasingly required of engineering graduates? The instructional methodologies include lectures, PowerPoint slides and visuals, case studies, quizzes, small group discussions, and group projects. We studied a sub-set of the leadership skills: developing higher-order cognitive skills, team working skills, positive attitude, and ability to transfer these skills to work environments in this study.

Research Model

In this section, we establish a research model, explain the model, define the terms used in the model, and then expand on the research questions.

Independent variables and their impact on dependent variables in the research model:

In order to answer the research question posed in the earlier section, we created the research model shown in Figure 1. The model shows the independent variables on the left and

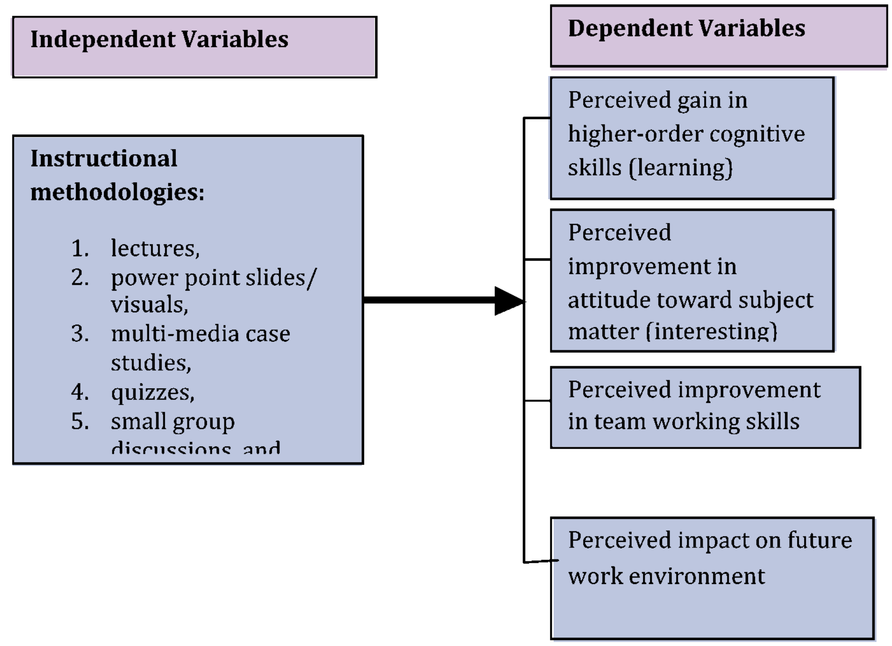

Figure 1: Research Model

the dependent variables on the right side of the figure. Each of these variables is further defined below.

Instructional methodologies:

- The lecture format is a traditional classroom setup in which the instructor leads the class through material from textbooks, etc. Knowledge is transmitted from the expert (here, the instructor) to the learner (Leidner and Jarvenpaa, 1995).
- PowerPoint slides and visuals enhance the lectures by adding visuals that bring elements that lectures cannot communicate. Also, slides may contain video clips that highlight some of the issues.
- Multimedia case studies, on the other hand, base learning on both individual and group interactions with the materials. The teacher discusses the theory in class, then conducts sessions in a computer laboratory in which the students analyze the multimedia case study in order to apply the theories to solve practical problems. In subsequent classes, the students present their recommendations and decide on the final outcome for the problem posed in the case study (Mbarika, Sankar, & Raju, 2003; Bradley, Mbarika, Sankar, Raju, & Kaba, 2007). Multimedia case studies are extended exercises that expose students to the complexities of problems they will face in the workplace. Case studies present an opportunity for students to develop a more complex understanding of the topics while developing their team

working and communications skills (Maxwell, Gilberti, & Mupinga, 2006). Multimedia case studies imply that at least one of the media (audio, video, or photos) supplements the written text. In addition, these are expected to be delivered using Web browser formats with hyperlinks, making it possible for students to peruse the case studies quickly and easily. Students will have the ability to switch among various menus and sub-menus. Use of a multi-media case study in a classroom requires the use of 3 to 4 class periods to discuss and analyze each case study. These also provide a multi-disciplinary approach to teaching engineering (Zirnheld and Halstead, 2008).

- Quizzes are used to evaluate whether the learning has taken place in the classroom. They tend to be short enough that students can normally complete them within 5 to 15 minutes. They require the students to answer questions in one or two sentences (Francis and Schreiber, 2008).
- Small group discussions include exercises in which the instructor stops the lecture, provides teams of students a few minutes to discuss the topic, and then gathers feedback. Students may be asked to report on their discussion. In addition, this might involve providing assignments related to Solid Modeling and generating engineering drawings in lab settings, where students are expected to interact with each other and with the instructor (Nikolic, 2002).
- Projects consist of a scenario that an instructor has created that requires the students to come up with solutions and implement them in order to conduct the project. Typically, projects are conducted by groups of students. An example of a project might be assembling a basic catapult from a kit supplied to them and then determining its performance. Other projects might be designing a solar-based hot water heater or an emergency water purification system, using 3D-conceptual modeling software, rapid prototyping techniques to design and fabricate a mold (Savage et al., 2007), a transportation vehicle capable of transporting a person over a given range and using a given energy supply, a battery-powered hovercraft capable of carrying a specified payload over a distance, and a mousetrap-spring-powered vehicle capable of transporting a specified load (Nikolic, 2002).

Higher order cognitive skills relate to the perception that an individual has acquired an adequate portfolio of skills to make a decision within a specified period of time. It implies an improved ability to identify, integrate, evaluate, and interrelate concepts, and hence make the appropriate decision in a given problem-solving situation (Hingorani, Sankar, & Kramer, 1998).

Team working skills are the set of interpersonal and communications skills that help individuals function in a team decision-making environment. Skills of this nature include listening skills, interpersonal relations skills, idea sharing, and consensus making. The more developed these skills are, the more likely and readily the student will adapt to the team environment in a real workplace (Olson, 2003).

The **positive attitude** of the student encompasses both the student's attitude toward the subject being taught and whether the student believes she or he will be able to learn the material. This includes emotional response to learning, confidence in learning new materials, responsibility, accomplishment, and understanding of cross-disciplinary work, all of which contribute to team working skills and higher order cognitive skills (Santhanam et al., 2008).

Impact on future work environment relates to acquiring skills that will stay with the person throughout life so that he/she uses the skills in future work environments.

Based on the research model, we developed the following research questions:

Question 1: Which instructional methodologies enhance students' perceived higher-order cognitive skills?

Question 2: Which instructional methodologies enhance students' perceived team working skills?

Question 3: Which instructional methodologies enhance students' perceived positive attitude toward engineering?

Question 4: Which instructional methodologies enhance students' perceived impact on future work environments?

Research Method

To test these hypotheses, we designed an experiment, which we will describe in this section. Here we will also describe the performance measures, the teaching methodologies and procedures used in two different sections of the course, and the data analysis methods.

Experimental Design

We decided to answer the research questions through responses obtained from students in two sections of an introduction to engineering course offered in a southeastern U.S. university. The objective of this course was to provide the basic skills an engineer will need to be successful in the workplace. These skills are:

- Basic math and science skills
- Team Skills
- Communication Skills
- Engineering Design Skills
- Business and Ethical Skills
- Decision-Making Skills
- Integration of Math and Science principles in Solving Engineering Problems

The first section was taught by a doctoral candidate with a few years of industrial experience. The second section was taught by an experienced professor with more than 25 years of experience. The students in the first section were mostly mechanical engineering students, whereas the students in the second section were mostly chemical engineering students.

Instructional Methodologies Used

The instructional methodology used in the first section used a mix of lectures, lab sessions, case study analysis presentations, and a design project. Students were provided theoretical materials related to an engineering topic using lecture sessions. Then, they analyzed a case study related to the lecture session in a computer laboratory (2 class sessions). The case study presented an engineering problem and provided multiple alternatives to solve the problem. A sufficient number of teams were created among the students so that each alternative could be assigned to one team to defend. In addition, one team was designated to take the perspective of the management. During the third week, the students defended multiple alternatives as solutions to the problem. The management team questioned them and, at the end, made a decision and presented it to the class. A course map was used as a basis for developing the course content so that the theoretical topics and the case studies could be integrated (Figure 2). The case studies used in this course map were available from the website www.liteecases.com as Web-based materials and also as a textbook. A detailed tutorial on how to implement a multimedia case study in an introductory course is provided in an article by Bradley et al., (2007).

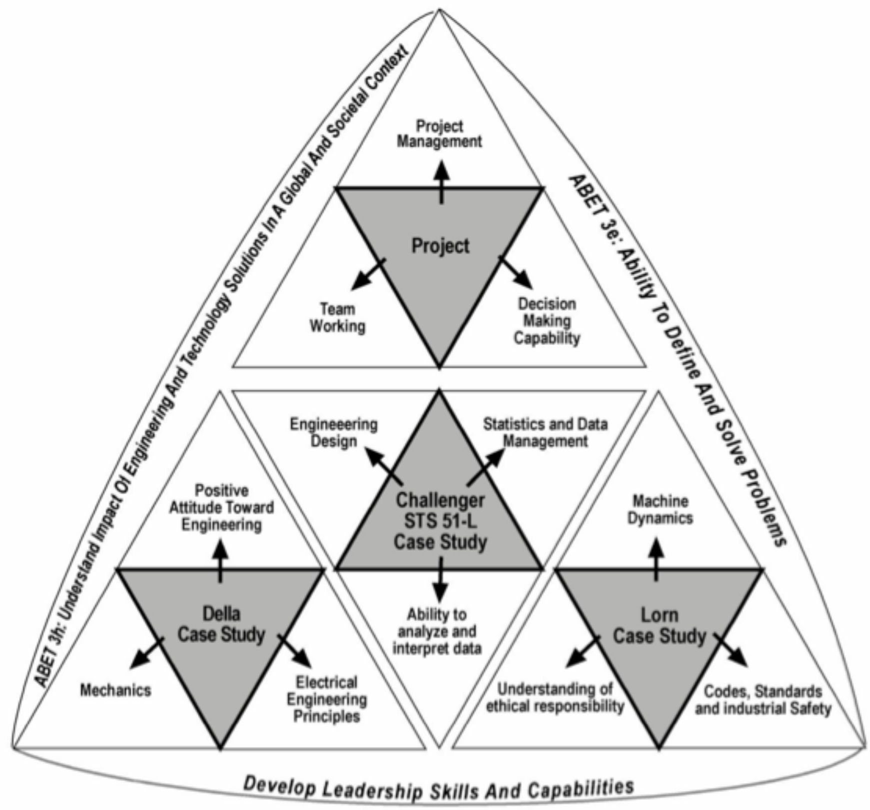

Figure 2: Course Map for First Section

The second section used the instructional methodologies of lectures, quizzes, small group discussions, PowerPoint slides, and a project to impart specific chemical engineering topics to the students using a textbook and evaluated the learning using tests at regular intervals.

Measures

Because there were several dependent variables, we used both quantitative and qualitative measures to find out the perception of the students about the effectiveness of the various instructional methodologies. We developed a survey that gathered students' background information and measured their perceptions on the different instructional methodologies (Appendix A). The survey instrument was developed based on earlier research done. The instrument used by Kramer, Sankar, & Hingorani (1995) became the basis for the development of the instrument used in this study. Hingorani et al. (1998) expanded the instrument used by Kramer et al. in an effort to assess whether students perceived improvement in higher-order cognitive skills. After this expansion of the instrument, others (Marghitu, Sankar, & Raju, 2003; Sankar Varma, & Raju, 2007) continued to refine it. The continued refinements led to

Construct	Survey Items	Cronbach Alpha
Cognitive Gains	15, 16, 17, 18, 19	0.859
Team Working Benefits	26, 27, 28, 29, 30	0.896
Positive Attitude to engineering	1, 2(rev),3,4(rev), 5(rev), 6(rev), 7, 8(rev), 9(rev), 10, 11, 12 (rev), 13, 14, 20, 21, 25	0.803
Impact on future work environment	22, 23, 24, 31, 32, 33, 34, 35,36	0.860

Table 1: List of Constructs and Items Used to Measure them

a more comprehensive instrument intended to measure the impact of instructional materials on the development of the dependent variables. In addition to the refinements made above, studies by Mbarika et al. (2003; 2001) have continued to validate the instrument. A College of Education faculty member further refined the questionnaire and came up with the questionnaire that is used in this research. The resulting questionnaire used in this study asked the respondents to indicate the extent of their agreement with 36 evaluatory statements on a 5-point Likert scale. The scale ranged from 1, "strongly disagree," to 5, "strongly agree." This questionnaire was modified in order to develop two versions: pre and post. Several qualitative questions were added to the survey so that the students' perceptions could be obtained. The students were assured that the survey was solely for the purpose of assessing the efficacy of the teaching methods and would not affect their course grades. They were implored to be as open and honest as possible in their responses. The pre-questionnaire was implemented at the start of the course and assessed students' expectations as a result of attending the course. The post-questionnaire was implemented at the end of the course and assessed what the students perceived they had learned as a result of attending the course. Therefore, the comparison was between the students' expectations at the start of the course and the perceptions at the end of the course on the dependent variables.

Procedures Used in the Both Sections

During the first week of the course, students completed the pre-treatment questionnaires as part of their course work. Then, the regular class was conducted using the instructional methodologies described earlier. During the last week of the course, students completed the post-treatment questionnaires as part of their course work.

Assessing the students in the first section consisted of awarding 55% credit for the case study team analysis and lab work, 25% for project, 12% credit for the individual assignments and attendance, and 8% for tests and quizzes. Assessing the students in second section included providing 50% for project, 15% for lab, 30% for quizzes, and 5% for professional development memos.

Data Analysis

Responses to questions on the survey were numerically coded in an Excel spreadsheet following the natural ordinal scale with the assignments: Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, and Strongly Agree = 5. In the interest of parsimony, many of the items were combined to form a total of four constructs that appeared to represent the essence of the perceptions elicited from the respondents. These constructs, along with the Cronbach alpha measure of their internal consistency/reliability are described in Table 1. The Cronbach Alphas were above 0.70 indicating that the items coalesced together well enough to represent the four constructs.

Four summated scales corresponding to the four constructs were formed by averaging the scores on the survey items identified with each construct. The change (post-treatment – pre-treatment) in the summated scores were calculated and employed as the dependent variables in four separate t-tests that were run in order to answer the research questions. In addition, 7 questions were asked in the pre-questionnaire and 11 questions were asked in the post-questionnaire in order to understand the relationships between the different instructional methodologies and the dependent variables. These

	First Section – PowerPoint, Case Study, Project			Second Section – PowerPoint, Small group discussion, Project			Difference in Post (controlled)	
	Mean	Stdev	n	Mean	Stdev	n	P-value	
Cognitive Skills								
Pre	4.11	0.39	66	4.11	0.59	39		
Post	3.48	0.74	52	3.42	0.84	33	0.461	
Post - Pre	-0.63	0.11		-0.69	0.17			
p-value	0.0000002			0.0001				
Teamwork								
Pre	3.85	0.46	66	3.88	0.85	39		
Post	3.61	0.74	52	3.55	0.85	33	0.335	
Post - Pre	-0.24	0.12		-0.33	0.2			
p-value	0.022			0.0527				
Positive Attitude								
Pre	3.73	0.0.28	66	3.65	0.34	39		
Post	3.66	0.38	52	3.33	0.56	33	0.0004	*
Post - Pre	-0.074	0.064		-0.327	0.111			
p-value	0.244			0.005				
Impact on Future Work Environment								
Pre	3.66	0.43	66	3.88	0.5	39		
Post	3.18	0.55	52	3.41	0.79	33	0.350	
Post - Pre	-0.48	0.09		-0.47	0.16			
p-value	0.0000007			0.0025				

Table 2: Results of Data Analysis of Engineering data for Spring 2008

were analyzed qualitatively in order to answer the research questions.

Results

This section provides the results of the analysis of the data collected from the surveys that were executed in the two sections. Table 2 shows the means and standard deviations for the differences between the post- and pre-survey for the four dependent variables for the two sections. A relatively high mean value implies a substantial difference between the post and pre values, whereas a low mean value implies a minimal difference between the post and pre values. Because the pre-questionnaire measured expectation and post-questionnaire measured performance at the end of the course, it is expected that the direction of the differences will be negative.

Open-ended questions were asked of students at the beginning and end of the semester. The numbers shown in the charts below indicate the number of students mentioning that coded theme in their response. Responses were coded by theme, then counted and en-

Theme	First Section Pre-Survey (66 students responding)	First Section Post-Survey (52 students responding)	Second Section Pre-Survey (39 students responding)	Second Section Post-Survey (33 students responding)
Lecture	31 (47 %)	17 (32.7%)	19 (48.7%)	8 (24.2%)
PowerPoint/visuals	28 (42.4%)	16 (30.8%)	16 (41%)	14 (42.4%)
Group projects	28 (42.4%)	30 (57.7%)	16 (41%)	14 (42.4%)
Individual projects	0 (0%)	0 (0%)	2 (5.1%)	0 (0%)
Small group discussion	0 (0%)	0 (0%)	6 (15.4%)	0 (0%)
Real life examples/problems	6 (9 %)	2 (3.8%)	2 (5.1%)	0 (0%)
Hands on activities	11 (16.7 %)	8 (15.4%)	4 (10.3%)	5 (15.2%)
Multi-media case studies	4 (6.1 %)	5 (9.6%)	3 (7.7%)	5 (15.2%)
Labs	1 (1.5 %)	5 (9.6%)	0 (0%)	0 (0%)
No response/None	16 (20.3%)	3 (5.8%)	15 (38.5%)	4 (12.1%)

Table 3: Response to Question on Helpful Instructional methodologies

tered into each chart to illustrate the numbers of student responses reflecting that theme. The number of students responding to each survey (pre- and post-) is listed in parentheses in the table headings. Percentages in parentheses indicate what percentage of students who responded to the survey mentioned that theme in their responses. Data results were presented in this way, because the students' responses to the open-ended questions were typically short answers that did not allow for in-depth narrative analysis.

Question: 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.)?

Table 3 provides answers to this question. Student responses in both classes, on both pre- and post-surveys, indicated a preference for lecture, powerpoints/visuals, group projects. In the first section, the percentage of student responses indicating a preference for lecture, powerpoint/visuals, hands on activities, and real life examples/problems decreased between the beginning and the end of the semester, while there was an increase in their preference for group projects, multi-media case studies, and labs by the end of the semester. In the case of students in second section, however, the percentage of responses indicating a preference for lecture decreased from the beginning of the semester (48.7%) to the end of the semester (24.2%), while there was a slight increase in the percentage of responses indicating a preference for powerpoint/visuals, group projects, hands on activities, and multi-media case studies.

Do you prefer to work alone or in groups to solve problems? Table 4 provides answers to this question. At the beginning of the semester, student responses in both sections indicated a high preference for group work over other formations for solving problems. At the end of the semester, percentages of student responses in the first section increased for both

Theme	First section Pre-Survey (66 students responding)	First section Post-Survey (52 students responding)	Second section Pre-Survey (39 students responding)	Second section Post-Survey (33 students (responding)
Group	33 (50 %)	27 (51.9%)	22 (56.4%)	18 (54.5%)
Alone	12 (18.1 %)	11 (21.2%)	9 (23%)	4 (12.1%)
No preference	18 (27.2 %)	11 (21.2%)	6 (22.2%)	4 (12.1%)
Alone, then group	1 (1.5 %)	0 (0%)	2 (5.1%)	0 (0%)
Depends	0 (0%)	2 (3.8%)	0 (0%)	1 (3%)
No response	15 (22.7 %)	1 (1.9%)	1 (2.6%)	5 (15.2%)

Table 4: Response to Question on Group Work

working in groups and working alone. Students who responded to the post survey in the second section showed a decreased preference for both group work and working alone.

What experience do you have with the engineering field of study? Table 5 provides the results obtained for this question. The table indicates that, in both sections, the majority of students either had no engineering experience or had only been exposed to engineering through coursework, independent study, or high school projects. At the beginning of the semester, 36.4% of the students in the first section and 69.2 % of students in the second section responded that they had no previous experience with the field of engineering; 39.4% of the first section students and 15.4% of the

Theme	First Section Pre-Survey (66 students responding)	First Section Post-Survey (52 students responding)	Second Section Pre-Survey (39 students responding)	Second Section Post-Survey (33 students responding)
No experience	24 (36.4 %)	9 (17.3%)	27 (69.2%)	18 (54.5%)
Coursework/Individual study/High school projects	26 (39.4 %)	26 (50%)	6 (15.4%)	5 (15.2%)
Some exposure (i.e., family, town)	2 (3 %)	2 (3.8%)	3 (7.7%)	2 (6.1%)
Work experience	9 (13.6 %)	6 (11.5%)	3 (7.7%)	1 (3%)
Internship	2 (3 %)	0 (0%)	0 (0%)	0 (0%)
No response	16 (24.2 %)	9 (17.3%)	0 (0%)	7 (21.2%)

Table 5: Experience in Engineering Field of Study

Theme	First section Pre-Survey (66 students responding)	First section Post-Survey (52 students responding)	Second section Pre-Survey (39 students responding)	Second section Post-Survey (33 students responding)
More interactive/ hands on activities	19 (28.8%)	5 (9.6%)	5 (12.8%)	4 (12.1%)
More time to do work/Less homework	0 (0%)	0 (0%)	1 (2.6%)	2 (6.1%)
Have different class time	5 (7.6%)	6 (11.5%)	0 (0%)	0 (0%)
Make it fun/interesting	6 (9.1%)	11 (21.2%)	5 (12.8%)	1 (3%)
Improved study habits	4 (6.1%)	0 (0%)	0 (0%)	0 (0%)
More/better lectures w/ labs	1 (1.5%)	5 (9.6%)	1 (2.6%)	2 (6.1%)
Fewer ppts.	0 (0%)	3 (5.8%)	0 (0%)	0 (0%)
More case studies	0 (0%)	2 (3.8%)	0 (0%)	0 (0%)
Fewer case studies	0 (0%)	2 (3.8%)	0 (0%)	0 (0%)
More group work	0 (0%)	4 (7.7%)	0 (0%)	1 (3%)
More History Channel	0 (0%)	1 (2%)	0 (0%)	0 (0%)
Less history	0 (0%)	1 (2%)	0 (0%)	0 (0%)
More technology	0 (0%)	2 (3.8%)	0 (0%)	0 (0%)
Better teacher	0 (0%)	3 (5.8%)	0 (0%)	3 (9.1%)
More guest speakers	0 (0%)	0 (0%)	0 (0%)	1 (3%)
Less computer work	0 (0%)	1 (2%)	0 (0%)	0 (0%)
No response/None	41 (62%)	12 (23.1%)	23 (59%)	17 (51.5%)

Table 6: Response to Question on Learning Experience

second section students indicated having had exposure to engineering in previous school work or through independent study. Interestingly, at the end of the semester, the number of students who reported having no experience with the field of engineering decreased in both sections, indicating that they were considering their coursework in this class to have added to their engineering experience.

What suggestions do you have for enhancing your learning experience in this course? Table 6 provides the responses to this question. The greatest differences in the percentages of student responses between the beginning and the end of the semester oc-

Theme	First section Pre-Survey (66 students responding)	First section Post-Survey (52 students responding)	Second section Pre-Survey (39 students responding)	Second section Post-Survey (33 students responding)
Improved teamwork	13 (19.7%)	12 (23.1%)	16 (41%)	12 (36.4%)
Career choices	8 (12.1%)	0 (0%)	7 (18%)	0 (0%)
Engineering principles	14 (21.2%)	10 (19.2%)	6 (15.4%)	3 (9.1%)
Better problem solving	9 (13.6%)	6 (11.5%)	3 (7.7%)	3 (9.1%)
Better communication skills	11 (16.7%)	7 (13.5%)	4 (10.3%)	3 (9.1%)
Better foundation/ Basic skills/ Employability	5 (7.6%)	5 (9.6%)	3 (7.7%)	6 (18.2%)
Don't know	8 (12.1%)	7 (13.5%)	0 (0%)	2 (6.1%)
Indeterminate answer	0 (0%)	2 (3.8%)	0 (0%)	0 (0%)
No response	20 (30.3%)	8 (15.4%)	3 (7.7%)	8 (24.2%)

Table 7: Response to Question on Impact on Future Work Environment

curred in the first section, where the percentages of student responses indicating a desire for hands-on activities/interactive assignments decreased from 28.8% to 9.6%. The first section student response percentages increased on such themes as having a different class time (from 7.6% to 11.5%), making it fun/interesting (9.1% to 21.2%), having more/better lectures with labs (1.5% to 9.6%), more group work (0% to 7.7%), and fewer PowerPoints (0% to 5.8%). In the case of students in the second section, the percentage of responses increased on such themes as having more/better lectures with labs (2.6% to 6.1%) and having more time to work on projects (2.6% to 6.1%). In number, the most comments related to their desire for a more interesting class; for example, students said:

- Please make it more interesting. More interesting lectures & more labs where we have to create something & less time sitting at a computer.
- Lectures were boring and pointless. Teacher went on about nothing. Make lectures interesting or fun or cut them out. Lab was okay, but 3 case studies got repetitive.

In the second section post-survey, there was a decrease (from 12.8% to 3%) in the percentage of student responses indicating a desire for more fun/interesting classes; it is possible to interpret this to mean that, by the end of the semester, students felt that the traditional class had been fun or interesting, or it may mean that they felt other factors were more important to report as being helpful to their learning experience. In both pre- and post-surveys for this class, the majority of students indicated no suggestions for improvement. The highest number of participants responding on the post-survey themes indicated that having more interactive/hands on activities would most enhance the course, similar to what they responded on the pre-survey. Summarized comments included their desire for more interesting class that had fewer or better lectures and more hands-on activities, more group activities, fewer PowerPoint presentations, and more guest speakers.

How do you perceive that you might use the information learned in this course in your future work environment? Table 7 provides a summary of the responses to this ques-

Theme	First section Post-Survey (52 students responding)	Second section Post-Survey (33 students responding)
Projects	28 (53.8%)	17 (51.5%)
Labs	13 (25%)	0 (0%)
Engineering principles/programs	6 (11.5%)	2 (6.1%)
Lectures w/guest speakers	2 (3.8%)	3 (9.1%)
Group work	2 (3.8%)	4 (12.1%)
Interactive activities	1 (1.9%)	0 (0%)
No response/none	6 (11.5%)	5 (15.2%)

Table 8: Response to Question on Helpful Learning Experience

tion. In the second section post-survey, the percentage of student responses that indicated their expectation that the course had improved teamwork potential on a future job decreased, yet on the post-survey of the first section, the percentage of student responses for that theme increased. This indicates that students who were exposed to the use of multi-media cases felt that their exposure to that treatment(s) in class was helpful to them in developing teamwork skills that would be useful to them in the future. There was a slight decrease in the number and percentage of students in both classes who responded that learning engineering principles would help them in a future job. In the first section, percentages of student responses decreased slightly for students believing that they had better problem solving skills, but increased for those believing they had a better foundation of basic skills as a result of having taken the course. In the second section, percentages of student responses increased slightly for better problem solving skills and increased for better foundation of basic skills. The percentage of responses by students in both sections showed a slight decrease on the theme of better communication skills.

What part(s) of this course did you find to be most helpful to you in learning the material? Table 8 provides a summary of responses to this question. Overwhelmingly, in both sections, students indicated their preference for the use of projects to learn the course material. Labs in the first section were identified by students as being very helpful in aiding them to learn course material. In the second section, 14 of the 17 students who mentioned project as being helpful specified the car/race design project, while students in the first section specifically mentioned the paper lab, the chip project, and Solid Edge labs. This may be interpreted to mean that, in both sections, the hands on activities and projects on which students work are perceived to be helpful to them in learning the course material.

What part(s) of this course did you find to be most interesting? Table 9 provides a summary of responses to this question. The students in the first section overwhelmingly found the labs, design and group work, as well as lectures, to a lesser extent, most interesting. Students who responded to the post survey in the second section indicated finding lectures, the design and group work, and PowerPoint presentations most interesting.

How beneficial would you rate the use of multi-media case studies in your learning material presented in this course? Table 10 provides a summary of responses to this question. Students from both sections indicated that case studies were beneficial to their learning the course material. In the first section where multi-media case studies were used on a regular basis, students who felt the case studies

Theme	First section Post-Survey (52 students responding)	Second section Post-Survey (33 students responding)
Labs	25 (48.1%)	0 (0%)
Design project	6 (11.5%)	5 (15.2%)
Group work	4 (7.7%)	5 (15.2%)
Lectures	5 (9.6%)	6 (18.2%)
PowerPoints	1 (1.9%)	4 (12.1%)
Reports/presentations	2 (3.8%)	2 (6.1%)
Technology	2 (3.8%)	0 (0%)
Hands on work	1 (1.9%)	0 (0%)
GTA/teacher	0 (0%)	2 (6.1%)
Text	1 (1.9%)	0 (0%)
No response/None/NA	11 (21.2%)	10 (30.3%)

Table 9: Response to Question on Interesting Learning Experience

were beneficial commented that the case studies made learning fun, gave them a real-world perspective of engineering, and enabled them to work in teams to solve problems. One student said:

- Very beneficial. They showed real world examples of what can go wrong and what can happen as a result. Also the split second decision that must be made.

Negative comments about the use of multi-media case studies included that they were not always relevant, they were repetitive, and the decisions to be made were common sense, rather than challenging students. As one student put it:

- The first few case studies were beneficial, because it was learning about something new, but after that they seemed pointless.

Students in the second section indicated that they liked the PowerPoint presentations and other visual aspects and enjoyed the guest speakers who came in to talk about their jobs and give insight into the work environment.

Theme	First section Post-Survey (52 students responding)	Second section Post-Survey (33 students responding)
Beneficial	24 (46.2%)	9 (27.3%)
Not beneficial	20 (38.5%)	1 (3%)
No response/NA	8 (15.4%)	23 (69.7%)

Table 10: Response to Question on Effectiveness of Multi-Media Case Studies

Theme	First section Post-Survey (52 students responding)	Second section Post-Survey (33 students responding)
Positive response	34 (65.4%)	13 (39.4%)
Negative response	6 (11.5%)	1 (3%)
No response/NA	12 (23.1%)	19 (57.6%)

Table 11: Response to Question on Effectiveness of Group Work

How helpful did you find the use of student groups/teams to solving the problems presented in the case studies? Table 11 provides a summary of responses to this question. In both sections, the majority of students responded positively that working with groups or teams was helpful to solving problems in the case studies. Students in the first section indicated that work in groups is "similar to a real-world job and give(s) students good experience with teams." Another said, "Getting different opinions from other group members was a big part of how to understand different view points before arriving at a solution." Three of the students in the first section mentioned the need to regulate the size of groups, saying, "it was hard to give everyone a job" and "the groups need to be small or they don't work together." In the second section, one student expressed a typical complaint that students have about working in groups:

- It was very helpful, but it is difficult when two people in your group do not do anything to contribute to the project. I do not think they should have a chance to make up that grade either.

What suggestions do you have for the instructor to improve his/her overall teaching in this course? Table 12 provides a summary of the responses to this question. In the first section, the most responses dealt with the instructor's presentation skills. Some of these responses were positive, such as, "he was very energetic during lectures," and, "he was more organized than most teachers I have." Other responses suggested that he "be more loose, not so uptight" and "be funny – yell and curse

Teacher related factors	12 (23.1%)	3 (9.1%)
Make it fun/interesting	11 (21.1%)	1 (3%)
Change the time of the class	5 (9.6%)	0 (0%)
More interactive/hands on	3 (5.8%)	5 (15.2%)
More design projects	2 (3.8%)	1 (3%)
Fewer design projects	1 (1.9%)	0 (0%)
More group work	1 (1.9%)	1 (3%)
More technology	1 (1.9%)	0 (0%)
More case studies	1 (1.9%)	0 (0%)
Fewer case studies	2 (3.8%)	0 (0%)
Fewer lectures /More ppt	2 (3.8%)	0 (0%)
Less history	1 (1.9%)	0 (0%)
No response/NA/none	16 (30.8%)	22 (67%)

Table 12: Response to Question on Suggestions for Improvement

– that'll get our attention" (so early in the morning) or "try not to just read the lectures word-for-word." Making it fun or interesting was a theme of their responses, including such comments as "make it less boring," "make it more interesting," or use "better stories and comparisons." Five (9.6%) of them commented that the early morning class start time of 8:00 a.m. was too early in the morning, and one of them mentioned that he/she would like for the labs to be earlier than 6 p.m. In the second section, students indicated that they would like to have more interactive activities to enable them to be engaged more in "doing engineering concepts and less hearing what they are." Two of the three responses that addressed the instructor suggested that he needed to speak louder and more clearly, fully explaining criteria. Another suggestion for the instructor was to post more examples for the projects.

Discussion

In this section, we discuss the results and show how they answer the research questions raised in an earlier section.

Which instructional methodologies enhance students' perceived higher-order cognitive skills?

The quantitative results in Table 2 show that students in both sections had a higher expectation about their cognitive gain in the start of the course (4.11 and 4.11) compared to the end of the course (3.48 and 3.42). Overall, the mean stayed above 3.0, showing that the students' expectations and perceptions on cognitive gains were positive as a result of attending the two sections. The qualitative results in Table 3 show that students in both sections preferred lectures, PowerPoint presentations and visuals, projects, real life examples/problems, hands-on activities, and multi-media case studies in order to help them learn new materials. On the post-survey in both sections, students suggested that lectures were monotonous and boring after a while. Though there were some comments indicating that students were bored with the use of so many PowerPoint presentations, they also mentioned how helpful it was to have concepts from the lectures summarized on the PowerPoint presentations (Table 9). Table 6 shows that the students indicated that having more interactive/ hands-on activities would enhance the course.

Tables 9 and 10 indicate that hands-on and interactive activities, such as design projects and multi-media case studies, were viewed very positively as tools to teach ethics, decision making, problem solving, and teamwork. Students also felt that they had been exposed, in varying degrees, to useful engineering principles that would benefit them in future work. Table 10 shows that the case studies provided students with a look at the applicability of some of the engineering principles they were learning. They commented that the case studies made learning fun, gave them a real-world perspective of engineering, and enabled them to work in teams to solve problems (Table 10). The multi-media case studies in general, along with other hands-on activities were able to hold students' interest while learning the engineering and design principles of the course. Students, however, suggested that the uniqueness and innovation of a new technology wore off rapidly through the semester as they became inured to its use in class. They suggested that two to three cases per course would be sufficient to teach the principles instructors were attempting to teach through the use of case studies and would prevent students from becoming bored and work from becoming repetitious. Table 8 also shows that students preferred the use of projects in order to learn the course materials. These projects included car/ race design project, paper lab, the chip project, and Solid Edge labs.

Which instructional methodologies enhance students' perceived team working skills?

The quantitative results in Table 2 show that students in both sections had a higher expectation about their team working skills in the start of the course (3.85 and 3.88) compared to the end of the course (3.61 and 3.55). Overall, the mean stayed above 3.0, showing that the students' expectations and perceptions on team working were positive as a result of attending the two sections. At the beginning of the semester, students in both sections indicated a preference for being taught course content via lectures, PowerPoint presentations, and projects as indicated in Table 4. The numbers of students who reported a preference for lecture at the end of the semester, however, decreased in both sections; while the reason for the decrease in reporting a preference for this mode is not known, it is possible that, after having just completed an intensive course that heavily relies on the use of lecture, students were simply not excited by the prospect of learning by lecture alone.

In both sections, students found that case studies and projects enhanced their team working skills. Students indicated increased interest in the use of group work to learn new material (Table 5), which indicates that students found group work, on the whole, to be a positive experience; however, there were several comments indicating that they should be allowed to choose their own group members for accountability purposes, that group sizes should be kept small to enable all members to participate and to evenly distribute work assignments, and that those group members who fail to participate should be penalized. Group work, on the whole, was viewed as a positive experience and provided students with different viewpoints and shared responsibility in decision making. Students in both sections valued the opportunities to improve their ability to work in a team setting. They were able to experience the process of making decisions and solving problems with a group and were exposed to the problems associated with group work, such as when each member does not participate. They also recognized the benefits, such as enabling them to hear others' perspectives and see viewpoints that they might not otherwise have considered. Group work also taught them the importance of being able to communicate one's ideas to others.

Which instructional methodologies enhance students' perceived positive attitude toward engineering?

The quantitative results in Table 2 show that students in both sections had a higher expectation about their attitude toward engineering at the start of the course (3.73 and 3.65) compared to the end of the course (3.66 and 3.33). Overall, the mean stayed above 3.0, showing that the students' expectations and perceptions on attitudes were positive as a result of attending the course. Although there was no significant difference between the pre-scores of sections one and two we found a significant difference between the post-scores, with section one having the higher score. This suggests that the use of multi-media case studies in the first section might have influenced the students to have a more positive attitude about engineering. The students in the first section overwhelmingly found the labs, design and group work involved in use of multi-media case studies, as well as lectures, to a lesser extent, most interesting. Students in the second section indicated finding lectures, the design and group work, and PowerPoint presentations most interesting. The students stated that instructors could make the instructions clearer and the class more interesting, less monotonous, and less repetitious. They also made suggestions related to presentation skills of the instructor, such as speaking louder, not reading from the PowerPoint slides, and speaking in a lively tone.

Which instructional methodologies enhance students' perceived impact on future work environments?

The quantitative results in Table 2 show that students in both sections had a reasonably high expectation about their perceived impact on future work environments in the start of the course (3.66 and 3.88) compared to the end of the course (3.18 and 3.41). Overall, the mean stayed above 3.0, showing that the students' expectations and perceptions of impact on future work environments were positive as a result of attending the course. The pre-survey and post-survey responses for both sections indicate some similar results (Table 3). Most students in both sections had little or no actual work experience, though some of them had been exposed to engineering principles through coursework, projects, or internships. Table 7 shows that in the second section post-survey, the percentage of student responses that indicated their expectation that the course had improved teamwork potential on a future job decreased, yet on the post-survey of the first section, the percentage of student responses for that theme increased. This indicates that students who were exposed to the use of multi-media cases felt that their exposure to that treatment in class was helpful to them in developing teamwork skills that would be useful to them in the future. The same pattern was found on the post-survey for their learning engineering principles; percentages of student responses in the second section decreased, while the percentage of student responses in the first section indicated that the engineering principles they had learned would help them in a future job. In both sections, percentages of student responses indicated that students believed that they had better problem-solving skills and a better foundation of basic skills as a result of having taken the course. Employability and basic foundation principles were improved, and students had the opportunity through these courses to become better problem solvers.

Implications for Research and Practice

Effective Instructional methodologies in an Introductory Class

The major conclusion is that there is a need to include hands-on activities such as projects, multi-media case studies, and labs in introductory engineering classes. The results clearly show the need for change in the instructional materials that are being used in introductory engineering classes. Glyer-Culver (2003) reported in a survey of students that they were not well prepared for leadership and decision making skills. Leidner and Jarvenpaa (1995) recommended that information technology be used to improve learning processes.

Multimedia case studies were well received by students in an introductory class, where they perceive improvement in their attitude toward engineering compared to another section where these materials were not used. The educational strategies used in developing the multimedia case studies—real-world examples, role playing as managers and executives, presentation requirements, and use of photos and videos—might be useful in the development of similar multimedia case studies. At the same time, students perceived that case studies started losing their effectiveness once there were more than 3 in a semester. Also, the instructor had to make sure the case study used was relevant and the decision was not only based on common sense, but on engineering principles also.

Projects were another important instructional material that need to be incorporated in introductory engineering classes. Students were able to apply the theoretical constructs learned in class to a well-structured situation to come up with a solution. Since most students did not have experience when they entered this course, it was important for them to work on projects so that they can see the applicability of the abstract theories to real-world problems. The students also were excited about the use of the projects in both pre and post surveys, indicating that their level of enthusiasm for working on projects remained strong throughout the semester.

Learning through work or real-world-based instructional materials, such as multi-media case studies or projects,offers advantages over traditional teaching and learning approaches (Wilcox, 2004). It provides opportunities for:

- Demonstrating the usefulness and relevance of learning to the work environment, thereby assisting the learning to become embedded in the learner;
- Linking theory to practice, so that the student is better able to understand the rationale for current procedures and, indeed, improve or develop current practice
- Applying new skills, knowledge, and understanding in the workplace to benefit both the employee and employer
- Developing the "soft skills" that will be required of the future engineer once he or she enters the modern workplace, and
- Demonstrating to the student the continuing and informal nature of the learning experiences in life that underpin continuing professional development.

Group work was also considered an essential instructional strategy to be followed in this course. Overall, most students preferred working in groups to learn new materials even though they did express stress involved with working in groups. The instructor had to ensure that the students in the group were properly rewarded for their work.

Need to rethink educational pedagogy given that number of students attracted to engineering field is decreasing

Kirsh et al. (2007) argued that women and minorities are not being attracted to engineering and computer science disciplines and the degree of inequality (gap between our best and least proficient) is among the highest in Organization for Economic Cooperation and Development (OECD) countries. OECD brings together the governments of thirty countries committed to democracy and the market economy from around the world. The earnings premiums are substantially higher for individuals who have higher cognitive skills, indicating that both education and skills contribute to individual opportunities (Kirsh et al., 2007). They stated that there is a need for new policies focusing on education and skill attainment.

An interesting research question is whether the current instructional methodologies are a contributing factor to this deficiency. This paper shows that instructional methodologies of projects and multimedia case studies were able to make a significant improvement in students' perceived higher-order cognitive skill gain and attitude toward engineering. Most engineering educators do not get adequate training on these instructional methodologies. Even though these results are encouraging, there is reluctance on the part of faculty members to adopt new instructional methods. In addition, the reward systems at most universities do not put much emphasis on widespread implementation of innovative instructional materials. Therefore, it is critical that more research be performed to further replicate and validate the results of this study.

In addition, other methodologies are available: industry projects, site visits, and problem-based learning modules, which might be able to achieve similar results. These were not implemented in the two sections that were studied in this paper. It is critical that research be conducted to evaluate the value of each of these methodologies. This paper contributes by proposing a research model, measurable constructs, and a set of questionnaires. Further experimentation by comparing other educational methodologies will be very valuable in enhancing the educational experiences of students.

Limitations

This paper reports on the results of an experiment to measure the perceived gains associated with the implementation of different instructional methodologies in an introductory class. The methodology has several limitations and they are discussed in this section.

Need for Longitudinal Results

The results are based on analyzing data obtained over one semester. It is important to repeat the experiment and run the model over several semesters and instructors. It will add to increased generalizability of the model. In addition, longitudinal tracking of students in the sections will add value to the study.

Need for measurement other than perceptions

A limitation of this study is that the reported results are based on the perceptions of the students. Another possibility is to track the students' career choices and employment offers after graduation. Unfortunately, students go through many different courses through their educational programs and it might be difficult to attribute their achievement to what they learned in one class. It would be interesting to survey students in a longitudinal study after they have begun their working careers to determine if their perceptions of the benefits of the course content and strategies/skills have changed. It is also possible to employ external evaluators to observe students at work and make generalizations based on such observations.

Need for more qualitative methodologies in collecting data

The use of survey open-ended questions was chosen logistically to facilitate the data collection process, yet the choice of interviews or focus groups that enable the researchers to acquire more in-depth data responses may prove more beneficial. Face-to-face qualitative methods, such as one-on-one interviews or focus groups, allow the researchers to ask students for examples of meaning and for elaboration of responses that are not as feasible with surveys.

Need to study other Leadership Skills

This study was limited in studying the impact of the case study methodology on only a sub-set of the leadership skills. It is critical to develop appropriate measures for the other leadership skills (Zafft, 2009; Farr and Brazil, 2009) and investigate how well this methodology helps develop them.

Development of a Causal Model

I n the future, it is possible to develop a causal model that links the acquisition of different skills to the overall performance in the course. It is also possible to test this model across different campuses by acquiring data on implementation in several sections.

Conclusions

Weber (2004) discussed students' difficulty in obtaining a deep understanding of and facility with higher-level skills without having first acquired a good knowledge of fundamental engineering concepts. He emphasizes the need for a broad, long-term perspective. The projects and multimedia case study methodology reported in this paper seem to have addressed the issue that Weber discussed: perceived acquisition of higher-level and leadership skills while having a reasonable knowledge of fundamental engineering concepts. This argues for the need for further research into adopting these instructional materials widely in other schools and for developing other innovative instructional materials. However, academics are slow to change given that producing research results requires years of work and that publication requires additional time. In the mean time, the instructional materials have a possibility of getting out-of-date, thereby providing educational benefits to only a limited number of students.

This paper shows that a few instructional methodologies—projects, multimedia case studies, and group work—can make major changes in students' perceived skill development in an introductory engineering class. It is imperative that administrators in universities and other policy makers in private and public grant agencies invest substantial resources to researching the effects of this and other instructional materials on students' leadership skill improvements and to providing rewards to faculty members to adopt these methods in their classrooms.

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Appendix A

Pre-Survey of Attitudes and Perceptions toward Engineering **Code #:**

The questions below are designed to identify your attitudes about Engineering. Be as honest as possible; there are no correct or incorrect answers. Your responses will not impact your grade in this course or in other courses. If you have very limited experience with engineering, then respond to the following questions with your expectation/beliefs. Please rate the degree to which you agree or disagree with the following statements in this questionnaire by bubbling in or clicking on the response according to the following 5- point scale.

A = Strongly Disagree (SD)
B = Disagree
C = Neutral (neither agree nor disagree)
D = Agree
E = Strongly Agree (SA)

Instructional materials are defined as the class lectures, text book, homework exercises, and innovative materials such as multi-media case studies that will be used in this course in the immediate future.

1. Engineering is a subject learned quickly by most people.	A	B	C	D	E
2. I have trouble understanding Engineering because of how I think.	A	B	C	D	E
3. Engineering concepts are easy to understand.	A	B	C	D	E
4. Engineering is irrelevant to my life.	A	B	C	D	E
5. I get frustrated going over Engineering tests in class.	A	B	C	D	E
6. I am under stress during Engineering classes.	A	B	C	D	E
7. I understand how to apply analytical reasoning to Engineering.	A	B	C	D	E
8. Learning Engineering requires a great deal of discipline.	A	B	C	D	E
9. I have no idea of what's going on in Engineering.	A	B	C	D	E
10. I like Engineering.	A	B	C	D	E
11. Engineering is highly technical.	A	B	C	D	E
12. I feel insecure when I have to do Engineering homework.	A	B	C	D	E
13. I ***can*** learn Engineering.	A	B	C	D	E
14. Engineering skills will make me more employable.	A	B	C	D	E
15. I expect to learn how to identify engineering tools that will assist me in decision-making using the instructional materials.	A	B	C	D	E
16. I expect to learn how to inter-relate important topics and ideas using the instructional materials.	A	B	C	D	E
17. I expect to learn how to identify various alternatives/solutions to a problem using the instructional materials.	A	B	C	D	E
18. I expect to improve my problem solving skills using the instructional materials.	A	B	C	D	E
19. I expect to learn how to sort relevant from irrelevant facts using the instructional materials.	A	B	C	D	E
20. I expect the instructional materials, class activities, labs, and assignments to be integrated in a way that makes my learning easier.	A	B	C	D	E
21. I expect use of the instructional materials to emotionally engage me in learning the course topics.	A	B	C	D	E

22. I expect using the instructional materials to increase my self-confidence.	A	B	C	D	E
23. I expect to achieve a sense of accomplishment in learning by using the instructional materials.	A	B	C	D	E
24. I expect using the instructional materials will help me assume a greater responsibility for personal learning.	A	B	C	D	E
25. If I ever were to become a high ranking engineer in a company I would hire other engineers to help with decision making.	A	B	C	D	E
26. I expect using the instructional materials will help me improve my team-building and interpersonal skills.	A	B	C	D	E
27. I expect using the instructional materials will help me and my classmates listen carefully to each other's statements and ideas.	A	B	C	D	E
28. I expect using the instructional materials will help me and my classmates arrive at decisions based on consensus building.	A	B	C	D	E
29. I expect using the instructional materials will help me and my classmates share ideas with each other.	A	B	C	D	E
30. I expect using the instructional materials will enhance my interactions with my classmates.	A	B	C	D	E
31. I expect my writing skills to improve as a result of this Engineering course.	A	B	C	D	E
32. I expect my presentation skills to improve as a result of this Engineering course.	A	B	C	D	E
33. I expect my confidence in applying Engineering concepts to real situations to improve as a result of this Engineering course.	A	B	C	D	E
34. I believe that an interdisciplinary focus is important in Engineering.	A	B	C	D	E
35 I expect using the instructional materials will improve my attitude toward Engineering.	A	B	C	D	E
36. I expect my informal communication skills to improve as a result of this Engineering course.	A	B	C	D	E

Scale: A = Strongly Disagree (SD); B = Disagree; C = Neutral (neither agree nor disagree); D = Agree;
E = Strongly Agree (SA)

Using the items provided below, indicate the item that best describes you

37. Please select one of the following for your years of work experience
(a) less than 1 year (b) 1 to 2 years
(c) 2 to 3 years (d) more than 3 years

38. Gender
(a) Female (b) Male

39. Race
(a) White (b) African-American
(c) Hispanic (d) Asian-American
(e) American Indian

40. Status
(a) Freshman (b) Sophomore (c) Junior
(d) Senior (e) Graduate

Please answer the following questions in as much detail as you can to enable us to improve the use of instructional materials in your course of study. We are interested in learning both what works and what needs improvement in the course. Your input will be kept confidential and will be used in our formative assessment to improve the program.

41. What experience do you have with the engineering field of study? (Include work experience, related courses or other experience with engineering)

42. 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.)

43. 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?

44. Do you prefer to work alone or in groups to solve problems?

45. What suggestions do you have for enhancing your learning experience in this course?

46. How do you perceive that you might use the information learned in this course in your future work environment?

Thank you for completing the questionnaire.

Post-Survey of Attitudes and Perceptions toward Engineering **Code #:**

The questions below are designed to identify your attitudes about Engineering. Be as honest as possible; there are no correct or incorrect answers. Your responses will not impact your grade in this course or in other courses. Please rate the degree to which you agree or disagree with the following statements in this questionnaire by bubbling in or clicking on the response according to the following 5- point scale.

A = Strongly Disagree (SD)
B = Disagree
C = Neutral (neither agree nor disagree)
D = Agree
E = Strongly Agree (SA)

Instructional materials are defined as the class lectures, text book, homework exercises, and multi-media case studies that have been used so far in this course.

1. Engineering is a subject learned quickly by most people.	A	B	C	D	E
2. I have trouble understanding Engineering because of how I think.	A	B	C	D	E
3. Engineering concepts are easy to understand.	A	B	C	D	E
4. Engineering is irrelevant to my life.	A	B	C	D	E
5. I get frustrated going over Engineering tests in class.	A	B	C	D	E
6. I am under stress during Engineering classes.	A	B	C	D	E
7. I understand how to apply analytical reasoning to Engineering.	A	B	C	D	E
8. Learning Engineering requires a great deal of discipline.	A	B	C	D	E
9. I have no idea of what's going on in Engineering.	A	B	C	D	E
10. I like Engineering.	A	B	C	D	E
11. Engineering is highly technical.	A	B	C	D	E
12. I feel insecure when I have to do Engineering homework.	A	B	C	D	E
13. I ***can*** learn Engineering.	A	B	C	D	E
14. Engineering skills will make me more employable.	A	B	C	D	E
15. I learned how to identify engineering tools that will assist me in decision-making using the instructional materials.	A	B	C	D	E
16. I learned how to inter-relate important topics and ideas using the instructional materials.	A	B	C	D	E
17. I learned how to identify various alternatives/solutions to a problem using the instructional materials.	A	B	C	D	E
18. I improved my problem solving skills using the instructional materials.	A	B	C	D	E
19. I learned how to sort relevant from irrelevant facts using the instructional materials.	A	B	C	D	E
20. The instructional materials, class activities, labs, and assignments were integrated in a way that made my learning easier.	A	B	C	D	E
21. The instructional materials emotionally engaged me in learning the course topics.	A	B	C	D	E
22. The instructional materials increased my self-confidence.	A	B	C	D	E

23. I achieved a sense of accomplishment in learning by using the instructional materials.	A	B	C	D	E
24. The instructional materials helped me assume a greater responsibility for personal learning.	A	B	C	D	E
25. If I ever were to become a high ranking engineer in a company I would hire other engineers to help with decision making	A	B	C	D	E
26. The instructional materials helped me improve my team-building and interpersonal skills.	A	B	C	D	E
27. The instructional materials helped me and my classmates listen carefully to each other's statements and ideas.	A	B	C	D	E
28. The instructional materials helped me and my classmates arrive at decisions based on consensus building.	A	B	C	D	E
29. The instructional materials helped me and my classmates share ideas with each other.	A	B	C	D	E
30. The instructional materials enhanced my interactions with my classmates.	A	B	C	D	E
31. My writing skills improved as a result of this Engineering course.	A	B	C	D	E
32. My presentation skills improved as a result of this Engineering course.	A	B	C	D	E
33. My confidence in applying Engineering concepts to real situations improved as a result of this Engineering course.	A	B	C	D	E
34. I believe that an interdisciplinary focus is important in Engineering.	A	B	C	D	E
35 The instructional materials improved my attitude toward Engineering.	A	B	C	D	E
36. My informal communication skills improved as a result of this Engineering course.	A	B	C	D	E

Scale: A = Strongly Disagree (SD); B = Disagree; C = Neutral (neither agree nor disagree); D = Agree; E = Strongly Agree (SA)

Using the items provided below, indicate the item that best describes you

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    (e) American Indian

40. Status
    (a) Freshman (b) Sophomore (c) Junior
    (d) Senior (e) Graduate

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43. 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?

44. Do you prefer to work alone or in groups to solve problems?

45. What suggestions do you have for enhancing your learning experience in this course?

46. How do you perceive that you might use the information learned in this course in your future work environment?

47. What part(s) of this course did you find to be most interesting?

48. What part(s) of this course did you find to be most helpful to you in learning the material?

49. How beneficial would you rate the use of multi-media case studies in your learning the material presented in this course? (Please explain in detail the benefits or non-beneficial aspects)

50. How helpful did you find the use of student groups/teams to solving the problems presented in the case studies? (Please explain in detail the ways in which working with other students in groups was helpful or not in your learning the course materials)

51. What suggestions do you have for the instructor to improve his/her teaching in this course?

Thank you for completing the questionnaire.