Use of Presage-Pedagogy-Process-Product Model to Assess the Effectiveness of Case Study Methodology in Achieving Learning Outcomes

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Abstract

In this paper, we integrate organizational, engineering education, and educational learning literature to develop a model of student learning so as to research how learning style, behavioral tendencies, gender, and race have the potential to act as facilitators or barriers to the learning process. We argue that the gains in higher-order cognitive skills, improvement in self-efficacy, and improvement in team-working skills are positively related to the absence of barriers to the learning process. The experimental design tests the model at two universities: Auburn University, a large land-grant institution in Auburn, Alabama, and Hampton University, an HBCU in Hampton, Virginia. Both groups of students were provided the multimedia case studies during Spring 2010.

The results show that the students prefer a visual mode of learning, that they were generally self-confident, and that they perceived an improvement in higher-order cognitive skills, team-working skills and self-efficacy after working on the case studies. At both universities, students overwhelmingly found the case studies and labs that involved building projects to be most interesting. Students found the multimedia case studies to be beneficial for improving teamwork skills, networking, problem solving, presentation skills, and communication skills. They mentioned that using the case studies helped them learn to research and make effective PowerPoints. Students also mentioned that the case studies helped their critical thinking and decision making skills. An unexpected outcome of this project was that the clinical supervision became an important outcome of the evaluation project. It provided a forum for the teaching, evaluation, and senior faculty teams to mesh together so as to improve the education of freshman engineering students.

I. Introduction

Learning can be characterized as changing one's way of experiencing some phenomenon; teaching, then, is creating situations where such change is fostered (Booth, 2004; Bransford, Brown, & Cocking, 2000). In any subject there is important content—phenomena, concepts, theories, principles, skills—and there are particularly productive ways of understanding these phenomena that form the backbone of the subject (Meyer & Land, 2003). Bowden and Marton (1998) claim that university students are engaged in learning for an unknown future and that instructors must design the curriculum with that in mind. Lamancusa et al. (2008) argue that a paradigm shift to industry-partnered, interdisciplinary, real-world problem solving is needed in engineering education. Rosalind Williams (2002, 2003) argued that "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 goes on to depict engineering education as needing to provide an environment in which 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. Such an approach to engineering education would certainly shift today's paradigm of instruction, leading it forward into a more innovative future.

The landscape of science, technology, engineering, and mathematics (STEM) education is dotted with islands of innovation—isolated areas where information technology-based (IT) materials are being used effectively (Falkenburg, 2004; Arreola, Theoll, & Aleamoni, 2003). Falkenburg stresses the need for new instructional pedagogies to be developed in order to use information technology more effectively in engineering classrooms.

Use of information technology and new instructional pedagogies may also help retain female students and minorities in engineering programs. Female students may experience debilitating anxiety in engineering courses and careers due to the stereotype or categorization of these fields as being predominantly male (Marra et al., 2009). Wulf (1998) stated that diversity is essential in engineering so that it can take advantage of life experiences that bear directly on good engineering design. The need for a greater push for diversity is borne out by the fact that Blacks and American Indians are less represented in the engineering field than in either science or non-science areas (Watson & Froyd, 2007). Few interventions have even attempted, much less demonstrated, that the interventions can improve deep cognitive abilities of the participants (Watson & Froyd, 2007; Cox & Cordray, 2008). These researchers stress the need for studies on innovative learning practices and instructional methodologies to identify their impact on students' learning.

In this paper, we integrate organizational, engineering education, and educational learning literature to develop a model of student learning to research how learning style, behavioral tendencies, gender, and race have the potential to act as facilitators or barriers to the learning process. We argue that the gains in higher-order cognitive skills, improvement in self-efficacy, and improvement in team-working skills are positively related to the absence of barriers to the learning process. We further argue that the instructional methodology is a moderating factor in the relationship of these variables with improvement in achieving learning outcomes. We derive a set of hypotheses based on the research model and test them using an experimental design. The targeted student groups for this experiment are freshman engineering students at Auburn University and Hampton University. An analysis of the data obtained from the experiment can further our basic understanding of the impact of instructional methodologies on student learning.

II. 4-P Model Description, Hypotheses

There is currently a call for significant breakthroughs in understanding how students learn engineering so that our undergraduate and graduate programs can prepare engineers to meet the needs of the changing economy and society (National Science Foundation, 2009). We answer this call by developing a model of student learning performance that offers new insights regarding the variables affecting the differences between the more innovative multimedia case study environment and the more traditional classroom context. We integrate bodies of literature from engineering education, business education, and organizational learning to come up with the research model.

We begin with the 3P (presage, process, product) model developed by Biggs and Moore (1993) to explain the factors affecting students' learning outcomes. The component *presage* encompasses characteristics that exist prior to engagement in learning, *process* incorporates the students' learning experiences, and *product* represents the students' learning outcomes (Nemanich, Banks, & Vera, 2009). Presage characteristics include such factors as gender, learning styles, behavioral tendencies, and race of the student. Process characteristics focus on the student's deep learning, which is based on motivation driven by interest in the course material and understanding of relationships among concepts, in contrast to shallow learning, which is based on motivation driven by desire to avoid failure and rote memorization of data (Kember, Biggs, & Leung, 2004). Presage and process characteristics intersect to determine the product: improvement in achieving outcomes (Kember et al., 2004). Cybinski and Selvanathan (2005) applied this model to compare statistics students in two different learning environments, and Nemanich et al. (2009) refined this model to compare students in classroom versus online settings. We add a fourth category called **pedagogy** to this model in order to measure the impact of different instructional methodologies on the learning outcomes.

We performed a review of engineering education literature to identify the factors that comprise the presage, pedagogy, process, and product factors (4P model) (Figure 1). We include **gender** as a presage factor because women are generally under-represented in engineering classrooms and in the engineering profession (Marra et al., 2009; Gowen & Waller, 2002; National Science Board, 2006). We include **learning styles** as a presage factor because they serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (Felder and Brent, 2005). The Index of Learning Styles (ILS) is an online questionnaire designed to assess preferences on four dimensions of a learning style model formulated by Felder and Siverman (1988). **Behavioral tendencies** were also included as a presage factor in this model because an even balance of students with different behaviors in teams leads to successful performance (Smith et al., 2005; Zywno, 2005). The DISC model, used in our experiment, is one of the oldest and most researched behavioral models (Marston, 1928) and provides strategies on blending and capitalizing on the behavioral tendencies of students in a team. **Race** was included as another presage factor because, in the U.S., African Americans constitute one of the largest minority groups who are significantly underrepresented in engineering. Of the engineering degrees awarded during 2003, African Americans received only 4.6% of the total, compared to 68.4% for whites, 7.4% for foreign nationals, 6.2% for Hispanic Americans, 0.5% for Native Americans, and 12.9% for Asian Americans (Engineering Workforce Commission, 2003). The percentage of engineering degrees earned by African American students drifted downward from 1999 to 2003 (Chubin et al., 2005), although there was an increase in the number of minority engineers produced by the U.S. in 2002, and African Americans remain one of the "grossly underrepresented" minority groups (Blust, 2001; Slaughter et al., 2003; Harvey, 2002).

Pedagogy refers to "the art, science, and profession of teaching" (Merriam-Webster, 2009). In this project, we constrain pedagogy to **instructional methodologies** alone because this factor has been recognized as important in engaging the current batch of Generation Net students (Chubin et al., 2008). The National Academy of Engineering (2004) recommended 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. Even though many different instructional methodologies are available, in this project, we only consider the lecture and LITEE (Laboratory for Innovative Technology and Engineering Education) multimedia case study methodologies.

We derive factors related to process based on a literature review and on ABET 2000 criteria. The ABET (2009) 3(e) criterion states that students need to be able to identify, formulate, and solve engineering problems at the end of their education. The teaching of domain-specific knowledge has long been recognized to be the primary objective of school and college education, but many students lack the breadth of knowledge and skills that are fundamental to the practice of their profession (Raju & Sankar, 1999; Aldridge & Benefield, 1997; Fergusson, 1992; Colby & Sullivan, 2008). There is now a growing realization among educators of the need to place a greater emphasis on **improving higher-order cognitive skills** (e.g., reasoning, critical thinking, decision making, problem identification, and problem solving) in engineering education.

We include **improvement in self-efficacy** as another variable in the deep learning process because it is related to students' plans to persist in the engineering discipline (Marra et al., 2009). Self-efficacy refers to individuals' beliefs in their capabilities to plan and take the actions required to achieve a particular outcome (Bandura, 1986). Efficacy applies to any situation; it is particularly important in choosing and executing constructive actions in situations that can be barriers to successfully achieving the ultimately desired outcome. In engineering, such a barrier might be negative stereotypes, active discouragement by peers or faculty, or scoring poorly on a calculus exam (Marra et al., 2009). A strong sense of self-efficacy, especially for women and minority students who are underrepresented in engineering classrooms, can help students persist and enable them to become practicing engineers (Chen et al., 2008).

We also include **improvement in team working skills** as another variable in the deep learning process because these skills are emphasized by employers and the ABET engineering criteria that emphasized an ability to function on multi-disciplinary teams (Meyer et al., 2005; Shuman et al., 2005). Many students have no prior experience working cooperatively in learning situations and, therefore, lack the needed teamwork skills to do so effectively. Instructors often fail to capitalize on much of the learning that can occur through group dynamics and behavior (Jones, 1996).

Learning outcomes define the final product of the 4P model. Learning outcomes are narrow statements that describe what students are expected to know and be able to do at the end of a course. These relate to the skills, knowledge, and behaviors that students acquire through a course (ABET, 2009).

Our integration of organizational learning, engineering education, and educational learning literature leads to the adaptation of the 3P model of student learning to develop a 4P model as shown in Figure 1.

III. Experimental Design

Our experimental design tests the 4P model at two universities: Auburn University, a large land-grant institution in Auburn, Alabama, and Hampton University, an HBCU in Hampton, Virginia. Both groups of students were provided the multimedia case studies in Spring 2010. Each semester, one section of Introduction to Engineering at Auburn University and two sections of Introduction to Engineering at Hampton University participated in the experiment. In Spring 2010, Joseph McIntyre taught Auburn's section, titled E*NGR 1110, Introduction to Mechanical Engineering*, while Qiang Le and Nesim Halyo each taught a section at Hampton, titled *EGR101, Introduction to Engineering*.

A main goal of the project was to control as many variables as possible in order to examine

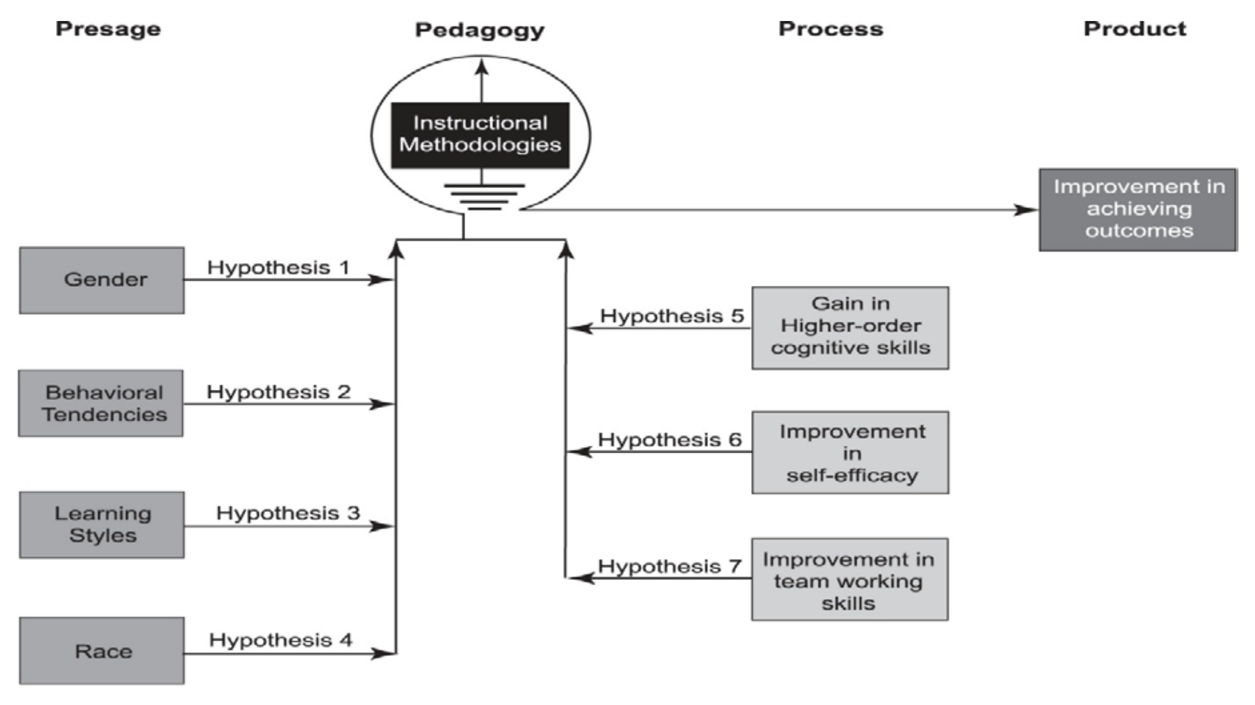

Fig. I Presage-Pedagogy-Process-Product (4P) Research Model with Instructional Methodologies as the Moderating Variable

the hypotheses; this goal drove our research plan and design. Prior to Spring 2010, the project investigators conducted weekly teleconferences and held a project meeting to design the courses as uniformly as possible. After referencing both Auburn's and Hampton's Introduction to Engineering course requirements, the investigators and instructors decided on course materials and planned their semesters week by week. They developed identical course outlines, timelines, and grading standards. Next, they developed and edited the contents of a textbook for the Introduction to Engineering course. The book, titled *Fundamental Leadership and Engineering Competencies* (ISBN: 978-1-930208-81-0), was published for the purpose of this project and was required for both Auburn's and Hampton's classes.

Three case studies were selected to include in the project: STS 51-L Challenger Design, Della Steam Plant, and Chick-fil-A Operating System. Each case study was carefully chosen for its relevance to certain course objectives. For example, through the Challenger case study, students are expected to learn fundamentals of engineering design and engineering ethics, among other principles. During the courses, students are given one week to conduct each case study. In the first class, students are introduced to the case studies and assigned roles to defend. In the second class, students make 12–15 minute oral presentations and debate.

Additionally, the project team selected two team projects to include in the curricula: "design of a pasta tower" and "design and testing of a paper parachute." These projects, chosen to supplement lectures and give students hands-on experience with engineering principles, were implemented in both control and experimental semesters.

Finally, the project team selected the following measurement instruments: the Index of Learning Styles (ILS), the Longitudinal Assessment of Engineering Self-Efficacy (LAESE), pre- and post-questionnaires developed by the project investigators, and student grades.

The Index of Learning Styles (ILS; Felder and Silverman, 1988) is a forty-item forced-choice instrument to assess preferences on four scales: active vs. reflective, sensing vs. intuitive, visual vs. verbal, and sequential vs. global learners. ILS is available from the website: http://www.engr.ncsu.edu/learningstyles/ilsweb.html. Active learners tend to retain and understand information best by doing something active with it—discussing it, applying it, or explaining it to others. Reflective learners prefer to think about it quietly first. Sensing learners tend to like learning facts; intuitive learners often prefer discovering possibilities and relationships. Visual learners remember best what they see—pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words—written and spoken explanations. Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it." The ILS is a well-established model for assessing students' learning styles.

The data from these instruments was collected by the teachers, coded by a designated member of the project team, and then evaluated by the project evaluation consultants. This allowed student data to remain confidential.

Self-efficacy was measured using the Longitudinal Assessment of Engineering Self-Efficacy (LAESE). Bandura (1997, p. 3) defined self-efficacy as "belief in one's capability to organize and execute the courses of action required to produce given attainments." It is logical then to assume that an increase in engineering self-efficacy is likely to lead to better performance in the classroom, and an increase in the retention of engineering students. The Longitudinal Assessment of Engineering Self-Efficacy (LAESE), developed by The Pennsylvania State University and the University of Missouri, and funded by The National Science Foundation, measures engineering self-efficacy. The instrument is designed to measure the change in self-efficacy in classroom settings where a program or activity is being undertaken related to student retention and student development (AWE, 2009). Using external experts, Marra, Rodgers, Shen, and Bogue (2009) determined the LAESE instrument to have sufficient content validity.

The LAESE collects data on a student's engineering self-efficacy in one of two ways: examining the results from the entire instrument, or examining the results from subsets of the LAESE items, designed to measure specific aspects of self-efficacy (AWE, 2009). The subsets of the LAESE include engineering career success expectations, engineering self-efficacy I, engineering self-efficacy II, feeling of inclusion, coping self-efficacy, and math outcomes expectations. We will use two self-efficacy subsets, engineering self-efficacy I and engineering self-efficacy II, to observe a change in self-efficacy. Questions are presented in two formats. The first format asks the respondent to rate the question on its importance using a 5-point Likert scale ranging from very unimportant (0) to very important (4), and to state their level of agreement with the question using an 8-point Likert scale ranging from strongly disagree (0) to don't know (?). The second format asks the respondents how confident they are in a situation using an 8-point Likert scale, ranging from strongly disagree (0) to don't know (?).

An Auburn University-developed questionnaire was used to measure the perceived constructs of higher-order cognitive skills, team working, and self-efficacy (Clayton and Sankar, 2009; Sankar and Clayton, 2009). Multimedia instructional materials have been recognized for enabling understanding of complex engineering and IT decision-making situations that require higher-order cognitive skills, which are needed for handling complex decision-making situations (Mbarika et al., 2003).

> **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 within the case study, and hence make the appropriate decision in a given problem-solving situation (Hingorani, Sankar, & Kramer, 1998).
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> **Team working skills** are the set of interpersonal and communications skills that help individuals function in a team decision-making environment. These skills include listening, interpersonal relations, 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, 2005). These skills are deemed highly important by employers and are among those emphasized by the ABET engineering criteria (Meyer & Land, 2003; Shuman, Besterfield-Sacre, & McGourty, 2005).
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> **Self-efficacy** is regarded as part of the deep learning process because it is related to students' plans to persist in their field of study (Marra, Rodgers, Shen, & Bogue, 2009).

This article discusses implementation of the experimental sections using multi-media case studies in Spring 2010. The total number of students taught using this methodology was 68 at Auburn University and 18 at Hampton University. The following section describes the results from this semester.

IV. Results, Spring 2010

Index of Learning Styles (ILS)

The results from implementing the Index of Learning Styles (ILS) in Spring 2010 classes at Auburn and Hampton Universities during the first week of classes provided a general description of the students' learning styles. Possible scores are from +11 to -11 on each dimension (visual versus verbal; sensing versus intuitive; active versus reflective; sequential versus global). Both groups had similar learning preferences as indicated by the means from the ILS (Table 1); Auburn students were more visual than Hampton students, but both groups preferred visual learning over verbal learning. Among the four learning styles, visual and sensing had the highest positive numbers. Otherwise, the two groups were remarkably similar:

- *Visual Learners:* Students prefer to learn through visual aids rather than through text or other verbal media.
- *Sensing Learners:* Students prefer to learn through data and facts rather than theories.
- *Active Learners:* Students to prefer to learn through doing something rather than thinking through concepts.
- *Sequential Learners:* Students prefer to learn step by step rather than looking at the big picture.

Longitudinal Assessment of Engineering Self-Efficacy (LAESE)

The results from implementing the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) in Spring 2010 classes at Auburn University demonstrated that students were generally confident in themselves and in their choice of engineering as a career. This was not implemented at Hampton University. The students at Auburn University felt included in the curriculum and perceived that they could cope with the coursework. These findings are summarized in Table 2. Means are based on a scale of 1 to 8.

Pre- and Post-Questionnaires

Pre and post questionnaires developed by Auburn University researchers at Auburn (n = 68) and Hampton Universities (n = 18) were designed to measure whether students perceived any improvement in higher-order cognitive skills, team working skills, and self-efficacy due to the introduction of multimedia case studies in these classes. The students were asked to complete the questionnaire at the beginning and end of the semester, and the responses were analyzed. The results show that students perceived improvement in their higher-order cognitive skills, team-working skills, and self-efficacy as a result of their experiences in their respective courses. All means were above 3.0 on a 5.0 scale. There was no statistical difference between the pre and post results for both universities. Table 3 below summarizes these results.

Learning Style	School	Mean
Visual	Auburn University	6.4
	Hampton University	3.4
Sensing	Auburn University	2.5
	Hampton University	2.4
Active	Auburn University	1.8
	Hampton University	1.8
Sequential	Auburn University	1.4
	Hampton University	1.8

Table 1: ILS Results

Regression Analyses

Three regression analyses were performed to determine predictor variables for various changes in variance: student performance, change in self-efficacy, and change in perceived higher-order cognitive skills.

- *Student Performance:* Students' prior GPA dominates all other variables in predicting performance in the class.

Measure	Definition	Mean
Career Success Expectations		6.05
Self-Efficacy I	Higher Grades	5.91
Self-Efficacy II	Ability to Complete Curriculum	6.00
Feeling of Inclusion		5.41
Coping Self-Efficacy	Can cope with the curriculum	5.78
Math Outcome Expectations	Students expect that they should be good in math to succeed in engineering	5.90

Table 2: LAESE Results

- *Change in Self-Efficacy:* Perceived changes in cognitive skills, team working skills, and learning styles explained 45.6% of the variance. All other variables accounted for an additional 3.9% of the variance.
- *Change in Perceived Higher-Order Cognitive Skills:* Perceived changes in future benefits, self-efficacy, and team working skills explain 65.4% of the variance. All other variables only account for an additional 2.2% of the variance.

Construct	School	Mean
Higher-order Cognitive Skills	Auburn University	3.19
	Hampton University	3.54
Team-working Skills	Auburn University	3.34
	Hampton University	3.81
Self-Efficacy	Auburn University	3.43
	Hampton University	3.52

Table 3: Pre- and Post-Questionnaires

Pre- and Post-Questionnaires: Open-Ended Questions

In the pre and post surveys, students were also asked open-ended questions to which they wrote responses. These were analyzed and common occurring themes were identified. The results are described in detail here.

Engineering Experience

Prior to taking the course, many students indicated having little or no experience with engineering. After taking the course, fewer students responded that they had little or no experience with engineering. This indicates that students may have felt they had obtained some experience with engineering through the course. On the post-semester survey, more AU students stated that they had work experience in the field than had reported having work experience at the onset of the course, and at both universities, more students indicated having related coursework at college, possibly as a result of this course.

Teaching Style

Students initially indicated a preferred teaching style that involved lecture, power point slides, and group projects. By the end of the semester, however, there was an increased interest in group projects (AU) and hands-on assignments (HU). Since much of the hands-on work involved group work, this seems to indicate that students at both universities preferred a teaching style that involved teams working on group projects. At both sites, there was an increase in the preference for the use of case studies; an increase in students' preference for multimedia was shown at HU.

Group Work

At both universities, students overwhelmingly preferred working in groups over working alone, both at the beginning and the end of the semester. There was a slight decrease in support of group work at the end of the semester over the beginning of the semester at HU. At AU, there was a slight increase at the end of the semester in the responses of students preferring both working in groups and alone.

Course Suggestions

More students provided no suggestions for an improved learning experience at the end of the semester than at the beginning. Students at both universities indicated the desire for more engaging lectures. At AU, students mentioned wanting more hands-on projects, though the same finding was not shown at HU. HU students did indicate on the post-survey that they wanted to participate in more group projects and case studies.

Future Careers

Students at both universities hoped at the onset of the course that they would find the information helpful to their future careers; however, in both cases, fewer students indicated at the end of the semester that they believed the information would be helpful in future work. Students mentioned that the course would be helpful to them in the future as they worked in groups and felt that they had learned more about teamwork from the course. At both universities, students indicated that they had improved their communication and presentation skills. There was an increase in the number of students at HU stating that the course information would be helpful to them in the future, though their responses were nonspecific.

Interesting Aspects of Class

At both universities, students overwhelmingly found the case studies and labs that involved building projects to be most interesting. At AU, 80% mentioned that the most interesting aspect of the course was the labs with group projects, while 35% of HU students also found labs with building components to be most interesting. At HU, 56% of students found the case studies to be of most interest to them, while 10% of AU student enjoyed the case studies as most interesting. Specific case studies mentioned were the Challenger, Lorn, and Chick-fil-A case studies. Three students indicated that they had found the course interesting, but they failed to specify in what respect.

Helpful Aspects of Class

AU students mentioned the lab exercises (35%) and the group projects (30%) as being most helpful, while HU students found the group projects and case studies to be most helpful to their learning (22% each). Also mentioned as helpful by HU students were the power point slides and practice exercises/examples. One specific problem mentioned several times by AU students was that the case write-up length is a problem. The student stated that the requirement is too long; it requires students to add fluff.

Case Studies: Mostly Beneficial, Some Caveats

Of the HU students, 30% found the multimedia case studies to be very beneficial to their learning (and 4% found it beneficial with caveats), while 53% of AU students found the case studies to be beneficial to some degree. Students found the multimedia case studies to be beneficial for improving teamwork skills, networking, problem solving, presentation skills, and communication skills. They mentioned that using the case studies helped them learn to research and make effective PowerPoints. Students also mentioned that the case studies helped their critical thinking and decision making skills.

Seven students indicated that the multimedia case studies were beneficial, but they had caveats. Some students felt that the cases were not related closely enough to course content. They also disliked being assigned a position to defend; they wanted to choose their own. Some students also disliked working on cases where the outcomes were already known (like the Challenger case).

25% of AU students and 9% of HU students did not find the case studies beneficial.. Students mentioned problems with the case studies. Some found the case studies to be boring, frustrating, pointless, or not current. Students also wanted more sides to take on an issue; they found that hearing presentations on the same three or four arguments every time became repetitive. Specifically, the Challenger case study was mentioned twice as being excellent.

Group Work

At both universities, students found working in groups to be helpful to solving the problems associated with the case studies. At AU, 75% of students found groups to be helpful or very helpful, while at HU, 48% of students indicated that working in groups was helpful or very helpful to solving the case study problems. Table 4 summarizes students' positive and negative feedback about group work.

Clinical Supervision:

In addition to the evaluation methodology

Positive Comments	Negative Comments
Group projects reinforced and applied course material related to teamwork.	The case studies could have been done alone; groups weren't needed.
It's easier to write papers as a group. It made the presentations easier to split up the work.	It is not helpful when all group members do not participate.
Group work taught me how to work with others (teamwork skills).	We got to come up with conclusions but didn't come to agreement.
Group work improved my communication skills/ interpersonal skills.	We should have been kept in the same group.
It made the workload easier, because we divided up the work.	Change group membership from project to project.
It allowed me to meet new people. I now have some new friends.	Nothing was done to make sure all participated.
Working in groups let us help each other and built camaraderie.	
It let us see other ideas/viewpoints/opinions.	
Working in groups helped us to avoid mistakes.	

Table 4: Comments about Group Work

used, the project required the senior faculty members meeting regularly with instructors and GTAs to discuss coursework and other professional issues in a structured way. The purpose was to help the instructors learn from their experience, deliver the technical materials, and be receptive to students. A conference call was held every week to ensure that the teaching faculty were supervised appropriately. The teaching faculty for this course were Joseph McIntyre at Auburn University, and Qiang Le and Nesim Halyo at Hampton University. We found that this clinical supervision was an important outcome of the evaluation project in that it provided a forum for the teaching, evaluation, and senior faculty teams to mesh together so as to improve the education of freshman engineering students.

V. Limitations and Future Research

This research does not report on the findings from when other instructional materials were used to teach students. It is important in the future to compare alternate instructional materials and evaluate how they impact the learning outcomes. It is also possible to include other instruments to evaluate the 4-P model. We are limited by the number of questionnaires that can be completed by students in a course. It is also critical to inform students of the results of the ILS and LAESE surveys. Frequently, we find it difficult to perform this activity since the evaluators tend to complete the analysis at the end of the semester; by that time, students have already completed the course. It also requires the instructors to become more aware of the evaluation methodologies. A challenge and future research activity is to develop a methodology to integrate the evaluation results so that the instructors can provide them to the students and make necessary modifications to the course. Then, the students will see the benefit of the evaluation activity. In addition, this study does not report results when multimedia case studies were not used in these classes.

VI. Conclusions

The project contributes to engineering education research and practice. First, by improving student motivation and involvement in the learning process, multimedia case studies could play a vital role in improving the representation of students in higher education engineering programs and, hence, improve the overall quality of engineering education. Secondly, based on the data gathered, the increased understanding of the learning styles of students helps the teachers design better instructional methodologies and curricula and thus create more suitable learning environments. This project adds to the body of knowledge on retaining minorities in engineering programs as a result of understanding which pedagogical strategies and learning opportunities are most conducive to their success. In addition, the findings from this research provide insight for any institution or program interested in retaining students in engineering and, possibly, any other STEM disciplines.

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