12-1-2010

Motivating Industrial Engineering Students: The Effects of Authentic Learning Experience, Gender and Class Standing

Danielle McDonnell
Clemson University

Maria E. Mayorga
Clemson University, mayorga@clemson.edu

Lisa C. Benson
Clemson University

Laine Mears
Clemson University, mears@clemson.edu

Journal of Applications and Practices in Engineering Education

Table of Contents

Beyond reluctance: Promoting learning through an unconventional approach to office hours 55
M. T. Balhoff and K. S. Jackson

Utilizing online forums within course management systems to create beneficial relationships between first-year students and practicing engineers 70
K. E. Bigelow

Motivating industrial engineering students: The effects of authentic learning experience, gender and class standing 79
D. McDonnell, M. E. Mayorga, L. C. Benson and L. M. Mears

Enabling remote learning and enhancing on-campus learning with web conferencing software 99
M. Plett and D. Peter

Using peer review to improve and assess writing 109
L. A. Zidek

Journal of Applications and Practices in Engineering Education, 1(2), 79-98, 2010.

MOTIVATING INDUSTRIAL ENGINEERING STUDENTS: THE EFFECTS OF AUTHENTIC LEARNING EXPERIENCE, GENDER AND CLASS STANDING

Danielle McDonnell, M.S. and Maria E. Mayorga*, Ph.D.
Department of Industrial Engineering
Clemson University
110 Freeman Hall (Box 340920)
Clemson, SC 29634, USA
*Corresponding author: Email: mayorga@clemson.edu

Lisa C. Benson, Ph.D.
Department of Engineering & Science Education
Department of Bioengineering
Clemson University
M-12 Hotzendorff Hall
Clemson, SC 29634, USA

Laine M. Mears, Ph.D., P.E.
Clemson University Mechanical Engineering
International Center for Automotive Research (CU-ICAR)
Campbell Graduate Engineering Center (CGEC)
4 Research Drive
Greenville, SC 29607, USA

This paper explores the attitudes and factors contributing to the motivation of Industrial Engineering (IE) students, and how these relate to various ASPECTS of their educational experiences. A mixed methods sequential explanatory study was used, starting with a survey (n=50) to assess different aspects of student motivation, followed by interviews with a smaller population of students (n=8). Survey data revealed that female IE students valued being students, and saw their coursework as more instrumental to their success, more than their male counterparts. Survey data also showed that students with university-sponsored authentic learning experiences had significantly higher expectations of success in IE than those without project experience. Eight themes were identified during interviews with students as things that contributed to their motivation: Altruism, Enjoyment, Goals, Nature of IE Field and Material, Personal Characteristics, Professional Identity, Relationships, and Resources. Based on these findings, recommendations were made to the program in terms of the IE curriculum and student projects.

Keywords: Engineering education, motivation, expectancy, authentic learning experiences

1. INTRODUCTION

Research has shown that motivation influences students' involvement and academic achievement (Gambrell, et al. 1996). It is defined as "the process whereby goal-directed behavior is instigated and sustained" (Schunk 1990). This implies that if a student has a goal to become a successful Industrial Engineer (IE), they will have the desire to reach this goal and will attempt to achieve the goal. Motivation is a fluid attribute that is affected by numerous factors, some that take place before learning has actually begun and

others during a student's education. Sometimes learners encounter events that increase their motivation to reach goals, bringing students closer to achieving their goals. However, learners can also encounter situations that cause a decline in motivation. This study aims to assess what factors into undergraduate student motivation to become IE's, which can be interpreted to mean their motivation to successfully complete the degree requirements and seek employment as an IE upon graduation.

This sequential explanatory mixed methods study intends to gain insight into what motivates a student to become a successful IE. A survey focuses on student attitudes about authentic learning programs and their benefits. Follow up interviews allow further exploration of survey results in terms of factors contributing to students' motivation to become successful IEs, but are not restricted to the context of authentic learning programs.

1.1. Assessing Authentic Learning Practices using Motivation Theory

Because of the multi-faceted nature of motivation, it is helpful to use a motivational theory as a framework for examining factors that contribute to student motivation. Modern Expectancy-Value theories have proven to be useful for college-age students. In general these theories recognize that in order for students to be motivated to pursue a major in college, they must have some expectation of success (expectancy) and they must value the goal they are working towards (value). Both of these constructs have been interpreted in different ways in terms of factors contributing to expectancy and value (Wigfield and Eccles, 1992; Eccles and Wigfield, 2002). One theory that seems appropriate for engineering students and their career goals is the Valence-Instrumentality-Expectancy (VIE) theory, which separates out students' perceptions of the usefulness (instrumentality) of a task in reaching their goals. According to VIE theory, motivation is a function of three perceptions: Valence, Instrumentality, and Expectancy (Vroom 1964).

Valence is the value the individual personally places on an action and its rewards, and thus is comprised of two components: Value of the Goal (V_g) and Value of the Behavior (V_b); i.e., value can come from participating in the activity (behavior) or the goal itself that the activity leads to. Value of the Behavior measures intrinsic characteristics of the activity. In this study, valence served as a measure of how much the students valued sharing IE projects with the community (V_b) as well as the value they placed on successfully entering the field of IE (V_g), which is assumed to be the goal of the IE students in this study.

Instrumentality is the perceived performance-goal relationship. It is the learner's perception that completing the behavior will increase the probability of accomplishing a future goal (Husman, et al. 2004). It has been theorized that tasks have more meaning if they are perceived to be useful in attaining goals that are valued by an individual (Green, et al. 2004). Students have a heightened interest in their schoolwork if they set future goals and can connect them to their present school tasks. This increase in interest increases motivation (Andriessen et al. 2006; Phalet et al. 2004), and contributes to the use of effective learning strategies and increased school performance (Simons et al. 2004; Andriessen et al. 2006; Phalet et al. 2004).

Expectancy is the expectation that one's effort will lead to the desired performance and is based on experience, self-confidence, and perceived difficulty of the performance goal. It is a measure of how likely a person believes he/she is to be successful at a behavior. A person must believe that he/she has adequate knowledge, skills, and resources to complete an activity. Expectations of successful completion of a task, or self-efficacy expectancy, affects whether or not an individual will initiate and continue a behavior. Efficacy expectations can be induced from four sources: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal (Bandura 1977). *Performance accomplishments* refer to actual, personal experiences that support personal mastery, such as successful completion of a task. In contrast, the observation of others' successful performance, or *vicarious experience,* can increase one's expectations that he or she can also be successful. *Verbal persuasion*, or the suggestion by others' that one can succeed at a task, is easily accessed by individuals, but is more limited than actual experience in affecting self-efficacy. An individual's level of anxiety or stress while performing a task, or *emotional arousal*, can affect his or her belief about success at the task.

Based on VIE theory, behaviors are inspired by a goal that will be reached if the behavior is effectively completed. As the values of the individual V, I and E components increase, the motivation to perform the behavior increases. Increasing any one element will result in an increase in motivation. VIE theory was chosen for numerous reasons, mainly because of its use in work-related motivation research (Van Eerde and Thierry,

1996), although it has been applied in an academic setting as well (Caulfield, 2007). Also, VIE theory treats Instrumentality as a separate construct, while others include it as a component of value (Eccles and Wigfield 2002). Instrumentality or a student's perception of a task's utility for the future, merits treatment as its own construct (Green et al. 2004). This is particularly applicable because of the nature of engineering education, and for the research questions being posed in this study. Due to the variety of roles engineers can play, it is impossible to teach exact tools they will use in the future in a classroom setting. Educators arm students with theoretical knowledge to help them solve problems in the future. If a student cannot see how the classroom content relates to the real world, they will be unwilling to learn the material and pursue their degree. Schooling differs from the work place; in the work place, everything is relevant in the present, but in school, students are mainly focused on the future and the relevance of the material they are mastering to their future. Thus future goals and aspirations are important to consider in assessing student motivation (Husman et al. 2004).

1.2. Rationale for Authentic Learning Practices

Authentic learning activities focus on real-world, complex problems and their solutions. Authentic learning activities take place in environments that are typically multidisciplinary, social, and similar to a 'real-world' application. Authentic learning activities often increase student motivation because they are meaningful to the life of the student and connect education to real life events. Often, learning is student driven with teachers, employers, and experts assisting and coaching the learning process (Lombardi 2007). This paper focuses on two university sponsored authentic learning activities, Creative Inquiry (CI) and Cooperative Education (Co-op). Therefore, throughout the rest of the paper we will use CI/Co-op in reference to authentic learning experiences.

Creative Inquiry (CI) is an undergraduate research program initiated at our institution that includes "all intensive, discovery-oriented approaches to learning." Undergraduates participate in research projects that intend to promote many valuable skills that will help them in their future careers. The projects encourage problem solving skills, critical thinking skills, teamwork, and communication skills. Students enroll in CI classes during regular school semesters.

Cooperative Education allows students to alternate semesters with schooling and paid career-related experience based at a company. The program aims to ease the transition between academia and industry by providing practical work experience and increasing students' understanding of business practices. In the department of the study participants, students who enroll in Co-op programs receive Pass/Fail Co-op credit hours. Many previous studies have been completed about cooperative education and undergraduate research. Cooperative education intends to ease the transition between academia and industry and dates back to 1906 (Thiel and Hartley 1997). Co-op programs are designed to give meaning to academic work, provide a chance to consider career opportunities to find a fit with a company or a desired field, allow training under practitioner supervision, increase maturity and self confidence, develop interpersonal skills, and allow students to earn money (Cates and Jones 1999, Thiel and Hartley 1997).

Most researchers agree that cooperative education provides beneficial experiences for STEM (Science, Technology, Engineering, and Mathematics) students and result in many academic and job related benefits, including higher grades and starting salaries, more timely job placement, faster advancements and promotions once employed, and increased "soft skills" such as communication and teamwork skills (Brumm et al., 2006; Blair et al. 2004; Wessels and Pumphrey 1996; Gardner et al. 1992; Fletcher 1989; Lindenmeyer 1967). Studies related to NSF Research Experience for Undergraduates (REU) programs dominate the literature related to undergraduate research experiences, although most are much different then Clemson University's CI program. Typically REU programs entail eight to ten week summer experiences (Pierrakos and Trenor 2009), but there are additional benefits from participating in research during the normal academic year at a student's home university. REUs are expected to be an intellectual-experiential process (Hunter et al. 2006), and are beneficial for participating students, especially those truly interested in the research topic. Benefits include increased research skills, improved analytical and metacognition skills, improved oral communication skills, increased productivity, self understanding, self identification as a "young scientist", and increased anticipation of graduate education and/or research as a career choice (Russell et al. 2007; Hunter et al. 2006; Russell, et al. 2005; Seymour et al. 2004; Kardash 2000; Kremer and Bringle 1990).

While these studies take into account academic and professional outcomes, they do not examine what allows students to be able to achieve them: *motivation*. Authentic learning activities are an instructional strategy that

intends to increase student motivation. This study aims to provide insight into student motivation so we can provide recommendations to authentic learning programs, such as CI and Co-ops, so that they make a positive impact on students, and produce high achieving, engaged students.

2. SURVEY METHODOLOGY

This cross sectional study takes a snap shot of student motivation at the time that this study took place. The study is interested in three variables: project experience, gender, and class standing. Students with university sponsored CI/Co-op experience were compared to students who had not participated in these university programs. While some of the respondents had participated in some type of summer internship or career-related employment, for the purposes of this study they were considered to be without experience because the university does not regulate students' summer experiences.

2.1. The Survey

The survey shown in Appendix A was constructed based on VIE Theory. Gender and class standing were self-reported, and the remainder of the survey consisted of 24 statements with Likert scale responses (values of 1 - 5 corresponded to strongly disagree, disagree, neutral, agree, and strongly agree). The responses were then recoded on a scale from -2 to 2, with 0 representing a neutral response. The research team mapped statements to one of the four VIE constructs (shown in Table 1; specific questions mapped to each construct can be seen in Appendix B). Each VIE construct was assessed, and each construct as well as the survey as a whole were evaluated for reliability. The construct reliability was measured using coefficient α and the question/construct correlation was measured using Pearson's coefficient of correlation (shown in table 1).

Table 1: Constructs and their Internal Consistency and Correlation with Individual Construct Items

Construct	Interpretation	Range of Question/ Construct Correlation	Coefficient α Reliability
Value of the Behavior (V_b)	*How much do the students value the process of sharing Industrial Engineering ideas and projects with the community?*	.49 to .75	.66
Value of the Goal (V_g)	*How much do the students value the benefits of the profession of Industrial Engineering?*	.45 to .83	.71
Instrumentality (I)	*Do students feel that sharing Industrial Engineering concepts outside of the university setting now will increase their likelihood of becoming successful industrial engineers in the future?*	.41 to .78	.70
Expectancy (E)	*After working with the Industrial Engineering ideas outside of the university setting, do they think they can successfully be an industrial engineer?*	.46 to .74	.62

Students enrolled in the Clemson University IE program were invited to participate in the study. Between December 2008 and March 2009, 50 students participated. The students were contacted during classes and via e-mail by a member of the research team. When considering project experience, the study had 27 students who had participated in some type of CI/Co-Op activities and 23 who had not. The division among grade level yielded 21 seniors and 29 underclassmen; the study had 23 female and 27 male respondents. Of those that participate in CI/Co-Op, 13 were female (14 male) and 12 were seniors (15 underclassmen). Since the sample size of our categories is small, a non-parametric statistical analysis was needed. The Mann Whitney test is the non-parametric equivalent to the t-test, which detects differences between medians for two different populations. A 10% level of confidence was used to determine significance. These precautions were taken to avoid false negatives or Type II errors (Walpole et al. 2007). Using this test our null hypothesis is that two independent

samples were drawn from the same population. Thus we reject the null hypothesis if the p-value is $<\alpha$; that is, in this case we conclude that there is a difference between the two samples. Thus, in the remainder of this section we report the p-value and median scores when comparing two groups in relationship to different constructs.

2.2. Survey Validity

Differences between class levels were computed to address the validity of the survey. The research team expected upperclassman to value the goal more than underclassman because they are closer to achieving it. The seniors were very close to receiving a degree in IE, and many of those who completed the survey had already been offered a job or were seriously looking for one. Statistical difference was observed between class grades. Upperclassmen, who had completed more credit hours, had higher median scores on the Value of the Goal construct; i.e. seniors valued the benefits and significance of Industrial Engineering more than sophomores and juniors. Results are summarized in table 2; this provides criterion validity for the survey. Another finding in this comparison is that the median score on the Instrumentality construct was lower for upperclassmen than for sophomores and juniors. While this difference is not statistically significant (with α=0.1), a possible explanation may be that the activity of sharing IE concepts outside the university setting was not a focus for the seniors; at this point in their educational experience, their courses themselves may be perceived as more instrumental in achieving their goal of entering the IE profession.

Table 2: Motivation Construct Comparisons by Class Standing: Results show median of aggregated responses for each VIE construct for upper (Senior) and lower (sophomore and junior) classmen as well as p-value and conclusion. Value of the goal statistically higher for upperclassmen.

Comparison Based on Class Year				
Construct	**Upper**	**Lower**	**P-Value**	**Conclusion**
Vb	1.00	0.83	0.749	Not Statistically Different
Vg	1.33	1.08	0.066	Statistically Different
I	0.83	1.33	0.101	Not Statistically Different
E	1.00	1.08	0.851	Not Statistically Different

2.3. Survey Results

Key differences were observed between motivation survey results for male and female students. Female students had statistically higher scores than male students in three areas, Value of the Behavior, Instrumentality and Expectancy; results are summarized in table 3.

Table 3: Results show median of aggregated responses for each VIE construct for female and male students as well as p-value and conclusion. Value of the behavior and Instrumentality are statistically higher for female students

Comparison Based on Gender				
Construct	**Female**	**Male**	**P-Value**	**Conclusion**
Vb	1.00	0.83	0.006	Statistically Different
Vg	1.33	1.17	0.270	Not Statistically Different
I	1.33	0.83	0.037	Statistically Different
E	1.25	1.00	0.036	Statistically Different

Another key finding was that students who had participated in CI/Co-Op programs had higher scores on all four motivation constructs than others did; this was statistically significant for Value of the Goal, Instrumentality and Expectancy (see table 4). Thus after sharing IE concepts outside of the university setting, students participating in these programs were more confident that they have the knowledge, skills, and resources to successfully become an IE. Furthermore, they placed higher value on the profession; we conjecture that this is because their experiences helped to shed light on what IEs do in the field.

Table 4: Motivation Construct Comparisons by Project Experience: Results show median aggregated responses for each VIE construct for students with and without CI/Co-Op experience. Expectancy is statistically higher for students with the experiences.

Comparison Based on Experience				
Construct	**CI/Co-Op**	**None**	**P-Value**	**Conclusion**
Vb	1.00	0.83	0.128	Not Statistically Different
Vg	1.33	1.17	0.033	Statistically Different
I	1.25	0.83	0.028	Statistically Different
E	1.25	1.00	0.019	Statistically Different

We can further block the results to look the effects of CI/Co-Op by class and gender. While the resulting sample sizes are too small to report effect sizes, we can make inferential conclusions. These results are shown in table 5. We observe that CI/Co-Op experiences have a positive effect on the motivation of female students with respect to all four constructs. This effect is not as pronounced or even present for all constructs for male students. Similarly, the positive effect of CI/Co-Op is stronger among lowerclassmen than senior students.

Table 5: Motivation Construct Comparison of Project Experience for each Gender and Class Subgroup

Median Response by Category Blocks						
		n	**Vb**	**Vg**	**I**	**E**
Female	CI/Co-Op	13	1.250	1.500	1.330	1.500
	None	10	0.917	1.167	0.833	1.083
Male	CI/Co-Op	14	0.833	1.167	0.750	1.167
	None	13	0.667	1.167	0.833	0.833
Upper	CI/Co-Op	12	1.000	1.333	1.000	1.25
	None	9	1.000	1.333	0.833	1.000
Lower	CI/Co-Op	15	1.000	1.333	1.333	1.167
	None	14	0.750	1.083	0.917	1.083

3. INTERVIEW METHODOLOGY

3.1. Data Collection

To further understand these results, the qualitative portion of the study sought to answer the research question, "How do students describe what contributes to their motivation to become an Industrial Engineer?" All students from the IE department at Clemson University were invited to participate in this part of the study. If they had not participated in the survey previously, they filled out a survey at the time of the interview. Three males and five females responded. Three of the five females and two of the three males had participated in university-sponsored CI/Co-Op programs. The class standing breakdown was two seniors, five juniors, and one sophomore. To protect student confidentiality, each participant was given a pseudonym.

An interviewer who did not have an active role in the students' education conducted semi-structured interviews with each student at the end of the spring 2009 semester. The interview protocol can be seen in Appendix C. Since the researchers designed the interview protocol to not be leading, it did not specify for the students to answer in the context of the survey. That is, the participants' responses were not limited to the specific behavior of participating in CI/Co-Op activities. Content validity was established for the interview protocol (DeVellis 2003) by having an expert in qualitative research review the interview protocol and make corrections to ensure that questions were appropriate, unambiguous, and would answer our research question. The participants' responses to the interviewer's questions were captured and documented using a digital voice recorder with their permission; audio recordings were professionally transcribed.

3.2. Data Analysis

One researcher and one independent consultant coded the interview transcriptions. An open coding approach was taken initially (Strauss and Corbin 1998), whereby coders independently read the transcripts and identified important quotes with little consideration as to their underlying meaning. Eventually categories began to emerge and the coders each created their own lists. Iterative inter-rated reliability checks were used to compare codes. During the first round of the check, the coders discussed each list of codes and created a master list by deleting, combining, and rewording the individual coder's work. Next, the axial coding phase began and the coders began to fit the data into an overall explanatory design (Strauss and Corbin 1998). Interviews were recoded and a second round of inter-rater reliability checks were conducted. Coders again reconciled differences and further clarified themes. The third round of the reliability check yielded a final inter-rater agreement of 100%, eight emergent themes, and 51 sub-categories.

3.3. Interview Results

The eight prevalent themes related to factors contributing to students' motivation to become successful IE's were altruism, enjoyment, goals, nature of the IE field and material, personal characteristics, professional identity, relationships, and resources. To support the emergent themes and claims, direct quotes from interview transcripts are shown in Appendix D. We summarize the emergent themes below.

I. *Altruism*: Many students cited a desire to better the world in several different ways. While some students specifically stated what they are interested in, others just want to have an impact at some point in the future.
II. *Enjoyment*: Many students listed pure enjoyment as one of the things that motivates them to be a successful Industrial Engineer. Students take pleasure in the material and the projects they work on. Students intrinsically value activities they are doing; this maps directly to Bandura's "emotional arousal" dimension of self-efficacy (Bandura 1977).
III. *Goals:* Students listed goals they set as well as goals that others have set for them as one of the drivers of their motivation. Specific goals varied among participants; some were focused on salary, while others focused on more immediate goals like making good grades and graduation. These "performance accomplishments" can be seen as contributing to efficacy expectations (Bandura, 1977). Others focused on making a contribution to a larger body, such as the department.

IV. *Nature of IE Field and Material:* Many students are motivated to become successful engineers due to the characteristics that are inherent to the field. Not only did they list the field as interesting, they also discussed its versatility. Participants discussed IE's benefits, applications, and even acknowledged useful topics. Finally, many of the students discussed how they liked that the field allowed them to work directly with people.

V. *Personal Characteristics*: Participants discussed many character traits that are necessary to become a successful IE. They agreed that some technical abilities are necessary, including intelligence, problem solving and analysis capabilities. Students also discussed the importance of being well-rounded and having good "soft skills", like communication, creativity, leadership, and organization. They discussed how their interest in the material, effort, drive, and persistence factored into their motivation. This theme maps to performance accomplishments, one of the theorized sources of efficacy expectancy (Bandura 1977).

VI. *Professional Identity*: This theme relates to how participants thought others viewed the field of IE and what they could do to improve it. Many students were concerned about the uninformed views of others and improving other's knowledge about IE. Most acknowledged the importance of showing the usefulness of the profession through their abilities.

VII. *Relationships:* Many of the students in the study stated that relationships they maintained with others factored into their motivation. The bonds formed in their school life, professional life, and home life had great impacts. The relationship could be between learners and their peers in and out of their major, family, faculty, and group members.

VIII. *Resources:* Participants realized the importance of utilizing resources to be successful one day. Resources come in all forms: time, money, and people. The students considered their friends, instructors, parents, and coworkers all people they could get help from. Students also realized that classroom material will probably be useful one day in the future.

Since several of the themes were mentioned multiple times, the percentage of total references each theme received is shown in figure 1.

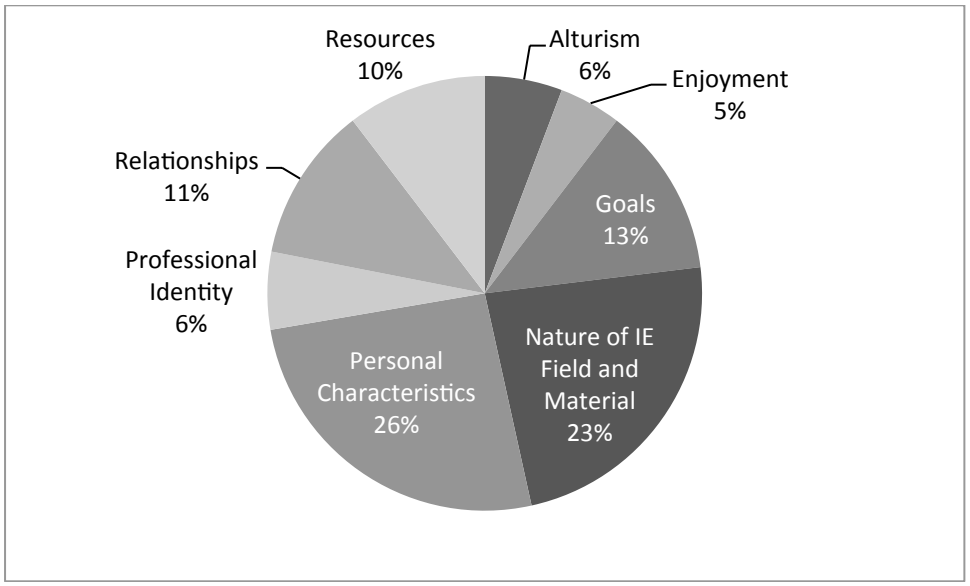


Figure 1: Distribution of Coded Responses. Eight themes identified through coding of interview responses.

Personal characteristics were referenced most frequently by students (26%). Within this theme, 21% of comments fit into the sub-theme of effort drive and persistence, 16% related to intelligence, and 12% were about the need to be truly interested in the material. The remaining 49% was comprised of a wide variety of topics from being creative to religious beliefs. The Nature of IE material and field made up 23% of students' responses. The most discussed sub-theme within this category is versatility (43%), comprising 10% of the coded responses. Other noteworthy sub-themes include IE's application and usefulness.

Table 6: Distribution of Coded Responses within Nature of IE Field and Material. Division of the Nature of the IE Field and Material theme into sub-themes.

Sub-theme	% contribution to responses
Versatility	**43%**
Application	**21%**
Useful Topics	**8%**
Benefits	**8%**
Narrow views	**8%**
Working with people	**7%**

Nineteen of the 51 total sub-themes were mentioned by more than 50% of the participants. In particular two of these factors were cited by all participants, versatility; and effort, drive, and persistence. The next most prevalent factors (mentioned by all but one participant) include enjoyment, gaining recognition, and having peers in the major.

4. DISCUSSION

The prevalent themes identified from interview data can be categorized into the VIE theoretical constructs (Value of the Behavior, Value of the Goal, Instrumentality, and Expectancy). Some of the themes contribute to more than one of the constructs based on how participants discussed them in the interviews.

I. *Value of the Behavior*: The factors that students discussed that could contribute to their value of the process of sharing IE concepts with the community are relationships, nature of the IE field and material, goals, personal characteristics, and enjoyment. These themes all address the students' satisfaction in sharing IE concepts with the community. Participants specifically mentioned their relationships with faculty, peers, and teammates would have a significant impact on their task value. Many students get pleasure from the IE field itself and take pride in IE material. Students like that the field is applicable, mobile, and versatile. Students also appreciate that it is an engineering field that involves working with people. One specific goal that students mentioned that would help students attach importance to the behavior was recognition. Additionally, personal characteristics such as enjoyment and interest in the material contribute to a student's value of sharing the material with others.

II. *Value of the Goal*: Themes that emerged that contribute to students valuing the benefits of the IE profession include altruism, personal characteristics, goals, and the nature of the IE field. Many students attach great importance to the fact that IE will allow them to make an impact on the world. Students believe that IE will help them to motivate others and improve the environment. Most students highly value the goals of getting a job that will allow them to make a good salary and live an adequate life style, being recognized as successful, and making contributions to society. The nature of the field and material also impacted how much students value the benefits of the field of IE, in particular the opportunity to work with people. They also mentioned their appreciation of how it is applicable, beneficial, versatile, and interesting.

III. *Instrumentality*: The original interpretation of this construct for this study was, "If a student shares IE concepts outside of the university setting will they perceive their educational experience as more useful in achieving their goals?" Because of the design of the interview questions, this construct was more difficult to document. Many students recognized that what they are learning will help them one day as members of the IE profession and that topics that they have learned in class could have an impact in a workplace setting. Also, several identified gaining recognition for the field which serves as a connection between sharing IE concepts with others and attaining their goal of becoming an IE.

IV. *Expectancy*: Emergent themes in participants' discussion of attributes needed to be successful were personal characteristics and resources. Students were very specific when discussing what personal characteristics are

needed to be a successful IE, and those that would also be needed when sharing IE concepts with others include communication skills, creativity, leadership, and organizational and project management skills. An important part of expectancy is perceiving that you have the resources to be successful, and students listed CI/Co-Op experiences as a relevant resource.

4.1. Comparison of Survey and Interview Results

Although survey results showed that all the students in this study had positive scores on the four measured motivation constructs, there were some differences in motivation between different populations. As defined by the constructs, the value of the behavior suggests that female students value sharing IE ideas and projects with the community more than males. The female students liked experiential learning programs more than males, finding them enjoyable and interesting. The interview data supported this finding. The females in this study mentioned that in order to be motivated, they had to be truly interested in the material they were learning, and they all expressed how much they enjoyed the material. *"I think you have to love what you do to be motivated so, which I guess it's not just for IE, it's for anything so, but especially if you're an IE you have to like doing it to be motivated to do it." (Hannah)* This sub-theme of interest in the material was not mentioned by any of the male participants. The literature also provides support for the difference observed in the survey data for the value of the behavior construct. The goals women rank higher are the desire to work at something they care about which often includes social causes (Seymour and Hewitt 1997).

The interview data did not directly support the survey results related to instrumentality and expectancy. The difference in the instrumentality construct suggests that female students believe participating in experiential learning projects directly relates to them becoming successful industrial engineers. Based on survey responses, students who participated in experiential learning had higher expectancy construct scores than students who did not. In other words, students who participated in these programs were more confident that they have the knowledge, skills, and resources to successfully become industrial engineers. The lack of agreement between survey and interview results could possibly be due to the voluntary nature of participant recruitment, and that the type of student who takes the extra time to participate in an interview has different underlying factors contributing to motivation than a student who committed to only taking the survey. In future research, the incentives for participating in the interview process should be higher to allure a broader population of students with a variety of underlying motivational factors.

5. CONCLUSIONS

Based on a survey about students' authentic learning experiences and how they relate to their goals of entering the IE field, female students enjoy authentic learning activities in IE, such as CI and Co-Op, more than males. Female students think participating in these activities will help them be better industrial engineers in the future. Students who participated in CI/Co-Op activities perceived that they have the ability to be a successful IE in the future.

Through interviews, eight emergent themes were identified that contribute to student motivation to become an IE. These are *altruism, enjoyment, goals, the nature of the IE field and material, personal characteristics, professional identity, relationships,* and *resources*. These themes offer further insight into the perceptions of IE students about their field and what motivates them to pursue it.

This study has demonstrated the value of surveying students to gauge the different factors contributing to their motivation. If other IE programs were to do this, they could personalize the learning experience to increase individual students' motivation to enter the field of IE. The survey and interview questions used in this study could be useful in guiding this type of feedback, and could be adapted to specific educational activities beyond CI-Co-Op experiences.

The participants in this study gave us further insight into what factors contributed to their value of engaging in CI/Co-Op experiences. Such authentic learning programs should stress relationships between faculty, peers, and teamwork to increase the value students place on them. Programs should highlight the parts of IE that students seem to appreciate the most, like versatility, mobility, applicability, and working with people. Also, by highlighting the goals of contribution and recognition, student motivation to purse the field of IE may also be

increased. The feeling of accomplishment gained by participating in experiential learning before reaching the ultimate goal (gaining employment as an IE) will help increase their motivation along the way.

Based on our interview data, students enjoy telling others about their work. Authentic learning programs should encourage students to share what they are doing as IE students with people outside the field. If projects showcased the many aspects of IE that students value (see table 6), it may result in an improved perception of IE as a career. If students care enough about their project to share it with others, their instrumentality will also be increased.

Finally, IE programs should help students develop the belief that they can successfully enter the field of IE. The identified classroom resources can be tapped to create activities that increase students' expectation of success in becoming an IE. Students in our study also recognized the characteristics necessary for success in IE; programs should strive to promote these skills to maximize students' engagement and motivation to pursue the field of IE.

6. REFERENCES

Andriessen, Iris, Karen Phalet, and Willy Lens. "Future Goal Setting, Task Motivation, and Learning of Minority and Non-Minority Students in Dutch Schools." *British Journal of Educational Psychology* 76, 2006: 827-850.

Bandura, Albert. "Self-efficacy: Toward a Unifying Theory of Behavioral Change." *Psychological Review* 84, no. 2, 1977: 191-215.

Blair, Benjamin F., Meghan Millea, and Joshua Hammer. "Impact of Cooperative Education on Academic Performance and the Compensation of Engineering Majors." *Journal of Engineering Education*, 2004.

Brumm, T. J., L. F. Hanneman, and S. K. Mickelson. "Assessing and Developing Outcomes Through Workspace Competancies." *International Journal of Engineering Education* 22, no. 1, 2006: 123-129.

Cates, Cheryl, and Patricia Jones. *Learning Outcomes: The Educational Value of Cooperative Education.* Maryland: Cooperative Education Association, 1999.

Caulfield, Jay. "What Motivates Students to Provide Feedback to Teachers About Teaching and Learning? An Expectancy Theory Perspective." *International Journal for the Scholarship of Teaching and Learning* 1(1). 2007:1-19.

DeVellis, Robert K. *Scale Development: Theory and Applications.* Thousand Oaks: SAGE , 2003.

Eccles, Jacquelynne S., and Allen Wigfield. "Motivational Beleifs, Value, and Goals." *Annual Review of Psychology* 53, 2002: 109-132.

Fletcher, Joyce K. "Student Outcomes: What Do We Know and How Do We Know It." *Journal of coopeartive Education* XXVI, no. 1, 1989: 26-38.

Gambrell, Linda B, Barbra Martin Palmer, Rose Marie Codling, and Susan Anders Mazzoni. "Assessing Motivation to Read." *Reading Teacher* 49, no. 7, April 1996: 518-516.

Gardner, Phillip D, David C. Nixon, and Garth Motschenbacker. "Starting Salary Outcomes of Coopeartive Education Graduates." *Cooperative Education* XXVII, 1992: 16-26.

Green, Barbara A., Raymond B. Miller, H. Michael Crowson, Bryan L. Duke, and L. Kristine Akey. "Predicting High School Student's Cognitive Engagement and Achievement: Contributions of Classromm Perceptions and Motivations." *Contemporary Educational Psychology* 29, 2004: 462-482.

Hunter, Ann-Barrie, Sandra L. Laursen, and Elaine Seymour. "Becoming a Scientist: The Role of Undergraduate Research in Students' Cognitive, Personal, and Professional Development." *Science Education* 91, no. 1, 2006: 36-74.

Husman, Jenefer, W. Pitt Derryberry, H. Michael Crowson, and Richard Lomax. "Insturmentality, Task Value, and Intrinsic Motivation: Making Sense of their Independent Interdependence." *Contemporary Educational Psychology* 29, 2004: 63-76.

Kardash, C. M. "Evaulation of an Undergraduate Research Experience: Perceptions of Undergraduate Interns and their Faculty Mentors." *Journal of Educational Psychology* 92, no. 1, 2000: 191-201.

Kremer, J. F., and R. G. Bringle. "The Effects of an Intensive Research Experience on the Career of Talented Undergraduates." *Journal of Research and Development in Education* 24, no. 1, 1990: 1-5.

Lindenmeyer, R. S. "A Comparison Study of hte Academic Progress of the Cooperative and the Four-Year Student." *Journal of Cooperative Education* 3, no. 2, 1967: 8-19.

Lombardi, Marilyn M. *Authentic Learning for the 21st Centry: An Overview.* Advancing Learning through IT Innovation, Educase Learning Initiative, 2007.

Phalet, Karen, Iris Andriessen, and Willy Lens. "How Future Goals Enhance Motivation and Learning in Multicultural Classrooms." *Educational Psychology Review* 16, no. 1, 2004: 59-88.

Pierrakos, Olga, and Julie Trenor. "Using a Mixed-Methods Approach to Investigate Students' Perceived Learning and Challenges Faced during a Summer Undergraduate Research Experience." *American Society for Engineering Education Annual Conference and Exposition.* Austin, TX, 2009.

Russell , S. H., M. P. Hancock, and J. McCullough. "The Pipeline: Benefits of Undergraduate Research Experiences." *Science* 316 (2007): 548-549.

Russell, S. H, C Ailes, M Hancock, M McCullough, and J D Roessner. *Evaluation of NSF Suppor for Undergraduate Research Opportunities: Survey of STEM Graduates.* SRI International. Menlo Park, CA, November 2005.

Schunk, D H. "Introduction to the Special Section on Motivation and efficacy." *Journal of Educational Psychology* 82, 1990: 3-6.

Seymour, Elaine, and Nancy Hewitt. *Talking About Leaving: Why Undergraduates leave the Sciences.* Bolder, CO: Westview Press, 1997.

Seymour, Elaine, Ann-Barrie Hunter, Sandra L. Laursen, and Tracee Deantoni. "Establishing hte Benefits of a Reserach Experience for Undergraduates in Sciences: First Findings from a Three Year Study." *Wiley Periodicals.* Wiley InterScience. 2004. www.interscience.wiley.com (accessed April 10, 2009).

Simons, Joke, Siegried Dewitte, and Willy Lens. "The Role of Different Types of Instrumentality in Motivation, Study Strategies, and Performance: Know Why You Learn, So You'll Know What You Learn!" *British Journal of Educational Psychology* 74, 2004: 343-360.

Strauss, Anselm, and Juliet Corbin. *Basics of Qualatative Research: Techniques and Procedures for Developing Grounded Theory.* Thousand Oaks: SAGE Publications, 1998.

Thiel, Glenn R., and Nell T. Hartley. "Cooperative Education: A Natural Synergy between Business and Academia." *Advanced Management Journal* 62, 1997.

Van Eerde, Wendelien, and Henk Thierry. "Vroom's Expectancy Models and Work-Related Criteria: A Meta-Analysis." *Journal of Applied Psychology* 81(5), 1996: 575-586.

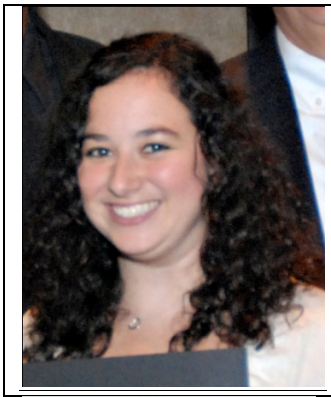
Vroom, Victor H. *Work and Motivation.* New York: Wiley, 1964.

Walpole, Ronald, Raymond Myers, and Sharon Myers. *Probability and Statistics for Engineers and Scientists.* Prentice Hall, 2007.

Wessels, W., and G. Pumphrey. "The Effects of Coopeartive Education on Job Search Time, Quality of Job Placement, and Advancement." *Journal of Cooperative Education* 31, 1996: 45-52

Wigfield, Allen, and Jacquelynne S. Eccles. The development of achievement task values: a theoretical analysis. *Development Review* 12, 1992:265–310.

BIOGRAPHICAL SKETCH

	Danielle McDonnell, received her B.S. and M.S. degrees in 2008 and 2009, respectively. She also completed the Certificate Program in Science and Engineering Education also from Clemson University. She is currently working for INTUITIVE Research and Technology Corporation as a Reliability Engineer.
	**Maria E. Mayorga** (corresponding author) is an Assistant Professor of Industrial Engineering at Clemson University. She received her Ph.D. in Industrial Engineering & Operations Research from the University of California, Berkeley. Dr. Mayorga has research and teaching interests in probability models and stochastic processes and optimization. She teaches courses in stochastic processes, dynamic programming and inventory management. Dr. Mayorga has authored over a two dozen publications in archival journals and refereed. Her research has been supported by NIH, BMW Manufacturing among others. She is a member of INFORMS is a board member for the IIE Operations Research Subdivision.
	Lisa C. Benson is an Assistant Professor in the Department of Engineering and Science Education at Clemson University, with a joint appointment in the Department of Bioengineering. Dr. Benson teaches first year engineering, undergraduate research methods, and graduate engineering education courses. Her research interests include student-centered active learning, student problem-solving skills, assessment of motivation, and effects of motivation on learning. She is active in the American Society for Engineering Education, Sigma Xi and the Society for Biomaterials. She earned a B.S. in Bioengineering from the University of Vermont, and M.S. and Ph.D. degrees in Bioengineering from Clemson University.
	Laine Mears is an Assistant Professor in Mechanical Engineering at Clemson University at the CU International Center for Automotive Research. His research in intelligent machining systems, manufacturing process modeling and control, manufacturing equipment diagnostics, and electrically-assisted deformation is sponsored by NSF, US DoE, NIST, and numerous industry sponsors including BMW. Dr. Mears has over 10 years' industrial experience in CNC machining, bulk deformation, and automated assembly processes. He received his Ph.D. degree in mechanical engineering from Georgia Tech, is an ASQ Certified Quality Engineer, and a licensed Professional Engineer. He chairs the ASME Manufacturing Technical Committee on Quality and Reliability.

Appendix A
IE Outreach and Real World Survey

IE Outreach and Real world Problems Survey

Code Name:	Gender:
Project Experience (Creative Inquiry, Co-op, Etc.):	Class Year:

For each question below, circle the number to the right that best fits your opinion on the importance of the issue.

Question	**Scale of Importance**				
	Not at all	**Not very**	**No Opinion**	**Some-what**	**Extremely**
I get satisfaction from presenting IE projects.	1	2	3	4	5
The field of industrial engineering is interesting.	1	2	3	4	5
Projects completed using IE knowledge are impressive.	1	2	3	4	5
Completing voluntary projects outside the classroom will benefit me in my career.	1	2	3	4	5
I feel proud when I tell people about Industrial Engineering.	1	2	3	4	5
I am considering choosing a profession where I would not use industrial engineering.	1	2	3	4	5
When I share things I learn in my major, other people are impressed.	1	2	3	4	5
IE tools can enhance a project.	1	2	3	4	5
My project experience will make me a better industrial engineer	1	2	3	4	5
I get satisfaction from educating people about Industrial Engineering.	1	2	3	4	5
I enjoy applying what I have learned in my classes.	1	2	3	4	5
I am fulfilled when I use IE tools to solve a real world problem.	1	2	3	4	5
Industrial Engineering is useful in a variety of industries.	1	2	3	4	5
When I graduate, I will continue in the profession of Industrial Engineering.	1	2	3	4	5
I want to continue using Industrial Engineering concepts in the future.	1	2	3	4	5
As an Industrial Engineer, I can make a good living.	1	2	3	4	5
Industrial Engineers are respected in society.	1	2	3	4	5
Industrial Engineering is a great career choice.	1	2	3	4	5
Participating in outreach projects will make me more marketable when looking for a job.	1	2	3	4	5
I enjoy showing others how IE tools can help them.	1	2	3	4	5
If someone had a problem, and I used IE tools to solve it, I would feel pleased.	1	2	3	4	5
Research experience reflects real world projects.	1	2	3	4	5
Research projects help me realize that industrial engineering is incredibly useful.	1	2	3	4	5
I feel fulfilled when I share a project with someone that I used IE tools to complete.	1	2	3	4	5

Appendix B

IE Outreach and Real World Survey Item/Construct Correlation

Item/Construct Correlations

Survey Question: How Outreach and Real World Problems Affect the Confidence and Attitudes of IE Students.

Mapping of Items to Constructs

Value of the Behavior: *How much do the students value the process of sharing Industrial Engineering ideas and projects with the community?*
1,5,7,10,20,24

Value of the Goal: *How much do the students value the benefits Industrial Engineering?*
3,8,11,13,17,21

Instrumentality: *If a student shares Industrial Engineering concepts outside of the university setting will they think the profession is more significant?*
2, 6,12, 16,18, 23

Expectancy: *After working with the Industrial Engineering ideas outside of the college setting, do they think they can successfully be an industrial engineer?*
4,9,14,15,19,22

Appendix C

Interview Protocol

Demographic information needed – Gender, Class year

Please describe what project experience you have participated in (Creative Inquiry, Co-op, etc.).

If CI or Co-op mentioned go to part A. If not, go to Part B.

Part A

What does motivation mean to you?

How would you describe your motivation to become an industrial engineer? Why? What factors are involved?

What does a person need to be motivated to be an industrial engineer?

What has affected your professional motivation to become an industrial engineer?

What knowledge, skills, and resources do you need to be a successful IE (essentially, what does it take to become a successful industrial engineer)? Did your project experience mentioned previously help you with develop any of these? How so? If not, why not?

Do you value the process of sharing IE ideas and projects with the community? Why or why not? What types of things do you share or value sharing? What types of audiences do you typically share projects with?

Did you enjoy your project experiences previously mentioned? What factors affected your enjoyment with the experience?

Can you describe some of the benefits of being an industrial engineer? How much do you value the benefits of industrial engineering?

Do you think that your project experience mentioned above will help you become a successful IE? Why or why not? What did you get out of those experiences that you think will help you become a successful IE?

Are there any additional variables affecting your academic motivation that we have not discussed today?

Part B

What does motivation mean to you?

How would you describe your motivation to become an industrial engineer? Why? What factors are involved? What does a person need to be motivated to be an industrial engineer?

What has affected your professional motivation to become an industrial engineer?

What knowledge, skills, and resources do you need to be a successful IE (essentially, what does it take to become a successful industrial engineer)?

Do you value the process of sharing IE ideas and projects with the community? Why or Why not? What types of things do you share or value sharing? What types of audiences do you typically share projects with?

What factors affected your enjoyment with the experience?

Can you describe some of the benefits of being an industrial engineer? How much do you value the benefits of industrial engineering?

How much do you value the benefits of industrial engineering?

Do you think that real world experience will help you become a successful IE? Why or why not? What would you consider to be real world experience?

What knowledge, skills, and resources do you need to be a successful IE (essentially, what does it take to become a successful industrial engineer)? What do you think are the most effective ways to acquire these skills/knowledge? Do you think real world or research experience affects any of these? How so?

Are there any additional variables affecting your academic motivation that we have not discussed today?

APPENDIX D
Direct Quotes to Supporting Emerging Themes

To support the emergent themes and claims, we quote the students directly from the interview transcripts. The quotes have not been altered for grammar or syntax, but to further protect confidentiality, any identifying words or phrases were altered. To increase understanding, annotations were made by the authors. Square brackets indicate these two types of changes.

I. *Altruism*:
   a. "I just knew whatever I did I had to feel like I was making a difference so I feel like being an IE I'll, in the real world, will enable me to do that." (Hannah)
   b. "To make the earth a better place in terms of how we engineer buildings or businesses and all the gasses emitted into the atmosphere, I think industrial engineering can have a huge impact on that." (Jackson)
   c. "My motivation is to succeed at what I'm doing and also help someone else along the way." (Oliver)

II. *Enjoyment*:
   a. "I like the people and the projects that we get to work on so again it goes back to something I like to do." (Lily)
   b. "I just enjoy it and I think with IE you can make everything better and that's really what I want to do is just find something that I love and make it better so that motivates me to be an IE I guess." (Hannah)

III. *Goals:*
   a. "Getting a salary, getting money, being able to move somewhere where I want to live." (Jackson)
   b. "I feel like I've always just had a drive to make good grades so I guess the grade part of it has motivated me to do well and therefore learn the material in my classes." (Hannah)
   c. "So in the academic realm I guess motivation comes from just maintaining a good GPA to get a job after college." (Billy)
   d. "I think that [Participating in CI] helped with the college experience…I felt like I was actually contributing to the industrial engineering department." (Ashley)

IV. *Nature of IE Field and Material:*
   a. "I felt like industrial engineering was more general and broad and it applied to more things. You can like look at almost any process and use industrial engineering so to me that was my motivation." (Ashley)
   b. "Yeah, there's something new every day. Like even if I worked – I worked for the same company two summers in a row but I never saw like the same problem occur, like it was something different, something new every day and even though it was something different and something new, you could still use industrial engineering principles and tools to solve them even though they were completely different." (Lily)
   c. "I mean when you start to understand like what we can do and what we're capable of like planning lives I mean, we can do, we can work for airlines and design the routes for the planes and the times and all that kind of stuff, you know, and I've never thought we would have done that so, I mean, you know, I definitely think that's – we definitely have a lot of options when we're looking for jobs. It's not just manufacturing and it's not just optimization. I mean we're all over the board so that's very, very beneficial" (Amber)
   d. I can always apply to a completely different field because I have no real restrictions. My degree will be cross functional across you know, many different types of jobs. (Billy)
   e. "It's almost like you're the eyes that you know, ten sets have seen something before but then when an IE looks at it, it's like flipping it around and seeing it from a different light. And the obvious things that IE's are used for is reducing cost and you know, increasing production. That's obvious benefits to the professional manufacturing world but even if it was in a different

industry such as healthcare you can make it more personable and you can really see the effects of what you're doing so." (Lily)

f. "I find all the topics that we've been covering very interesting so it's, it's very motivating to actually see this working and you know, you see what you're doing in class and how it's going to be used in the real world. (Amber)"

g. "My professional motivation is to make an impact in whatever way I can to help other people because at sometimes other disciplines in the engineering field feel like less personal and IE you actually get an opportunity to work with people and change their lives so that's what I want to do." (Oliver)

h. "I definitely like working with people. I originally wanted to be a civil engineer and after doing an internship with a commercial construction company, [], I realized I didn't want to do that anymore. I didn't want to work on drawings all day. I like, you know, having basically some kind of user and or customer and being able to take their needs and their wants and you know, design and improvise and innovate into some sort of project or you know, whatever product they're looking for, so I think it's a lot more interactive with a person."

V. *Personal Characteristics*:

a. "have a certain kind of problem solving mind. You have to be able to look at the big picture and not at one isolated incident even though you're, what you're trying to solve may seem isolated. It's really a bigger picture so you have to be able to look at a broader scope." (Oliver)

b. "Well you definitely, you have to be kind of smart, you know. You have to take all the calculus classes and the physics… You have to be able to use a lot of logic for the computer coding and things like that, the optimization, you know, coding." (Jackson)

c. "but I still think when it comes to stereotypical IE positions, presentation skills, communication skills, you know, things like that are more important almost than your technical knowledge. (Lily)

d. "So I think you have to be kind of like a, just a very creative person. Maybe a little bit of a dreamer, just you know, imaginary person I guess" (Jackson)

e. "I mean you obviously need leadership skills and management skills as far as your time and what you're working on, you know. I mean if you can't get along with your boss that's not going to help the matter either so I think there are a lot of factors that really play into being a successful IE." (Amber)

f. "Oh, I guess motivation to me is being able to get up and get something done and like I guess self motivation would be like for me myself to get myself pumped about doing something and then going out and actually doing it" (Ashley)

g. It [motivation]just has to be there or not so something I just want to say that I did just for myself and be successful at it." (Lily)

VI. *Professional Identity*

a. "I think a lot of people don't realize what IE's are. You tell people you know, majoring in industrial engineering and they're like you know, what is that, and they don't see the importance of us." (Amber)

b. "they sort of look down on the industrial engineers and I sort of find myself defending my major on a consistent basis so I try to explain to them that what I do is actually necessary and it's not something that anyone could do." (Billy)

c. "I would say just our capabilities in terms of how we can use our tools and what we know along with what their specializations are I guess, you know, if it's an ME, you know, what sort of machines they can design and then how we can take that and incorporate into a bigger picture. Maybe along with you know, some kind of material science or packaging or you know, civil engineers that can design bigger buildings and just things like that (Jackson)

d. "It's really cool to see, or to go into a facility or an area or industry even that hasn't maybe even heard of what an industrial engineer does and we're like we can make things more efficient and

we can save you money and they're like all right. So yeah, I definitely think it's something we should definitely share and get the word out about." (Lily)

VII. *Relationships*

a. "I feel like also you need a good group of friends that, whether in the major, and people getting to know people in the major, you need to have a good relationship with your professors so they can help you succeed." (Oliver)
b. "It's actually very motivating when your professors actually care whether you pass the class or not and they're very helpful…it's good to have people in our department that actually are enthusiastic about our major so that helps you a lot." (Amber)
c. "all the staff, the IE, the professors, everybody's always really willing to help you out and wants you to succeed and always really available to help and TA's and everything I've experienced so far." (Roxy)
d. "Well, my stepdad has been in human resources for over 30 years and he recruited heavily at Clemson in the IE department and he was like they are extremely marketable right now and you know, that had a really big play into what I wanted to do." (Lily)
e. "a big influence on my life is my sister and she came to Clemson and she did industrial engineering and we're similar people even though we have our differences, but I can see why she chose the major because it fits me as well. (Oliver)

VIII. *Resources*

a. "I mean, obviously paying attention to your classes because believe it or not like they are really, I mean they're pretty much on target as to what's really going on out there." (Amber)
b. "You have to be able to use resources. You know, I use TA's and my teachers' office hours and my peers for homework and you know, all that sort of stuff so you really have to be able to interact with other people and at, you know, admit when you don't know something, ask for help. (Jackson)"
c. "And my dad's an engineer and so, actually the other day I had a question about lean manufacturing and Kankan and so I was able to talk to him about it. He works at Michelin so it's a very, it's, yeah, it's very interesting and it helps when, you know, you have a family member or someone that you can talk to and I could still have my contacts at Michelin that I can call up and talk to them about it, too, so." (Amber)