8-2009

INCREASING STUDENT MOTIVATION TO BECOME A SUCCESSFUL INDUSTRIAL ENGINEER

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INCREASING STUDENT MOTIVATION TO BECOME A SUCCESSFUL INDUSTRIAL ENGINEER

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Masters of Science
Industrial Engineering

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by
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August 2009

Accepted by:
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ABSTRACT

This paper explores the use of the VIE theory of Motivation in the field of Industrial Engineering Education. This work focuses on two different populations of students, college students who have chosen Industrial Engineering as a major and middle school students with a predisposition toward engineering. To start, we used a mixed methods sequential explanatory study to learn more about Clemson University department of Industrial Engineering students. Quantitatively, the study found that differences exist among different subsets of Industrial Engineering students. Female students have a higher motivation than male students do, and students with university sponsored project experience have a higher motivation than those who do not have the project experience. Qualitatively, 8 themes were identified by students as things that contributed to their motivation: Altruism, Enjoyment, Goals, Nature of IE Field and Material, Personal Characteristics, Professional Identity, Relationships, and Resources. Next, a quantitative study was conducted to determine the effectiveness of Industrial Engineering modules into a middle school pre-engineering class. Pre and post surveys were used to measure if students motivation to pursue industrial engineering increased over the course of the year. While no statistical differences were proven, anecdotal evidence proved the program was a success despite the inability of the quantitative tool to prove it. Using the VIE Theory of Motivation recommendations were made to both programs, the Clemson University Industrial Engineering Department and future engineering educators in the middle school setting.

ACKNOWLEDGMENTS

First I would like to thank other students who contributed to this research. The undergraduate team of students who helped complete the project with the middle school students: Lindsay Balint, Marissa Grubb, Audrey Berger, Kelly Springfield, and Darla Browning. Emily Medders, who helped code the interview data to establish inter-rater reliability.

I would like to thank my committee for all their help and support. They were a fantastic committee, the best any student could find! Maria Mayorga helped me every step of the way. She is a fantastic advisor. Dr. Lisa Benson is a incredible resource who always found time in her busy schedule to help me! I would also like to help thank the members of the Education and Science Education Department for their unwavering help and support, especially Zahra Hazari, Geoff Potvin, and Marissa Orr. Their support and advice were essential to the completion of this work.

I would like to thank my roommate, Kimberly Cellucci, for helping me very much, even though it was not in a research sense. She was amazing at supporting me and forcing me to work on it! She is the best friend a girl could ask for.

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CHAPTER ONE

INTRODUCTION TO MOTIVATION AND THE VIE THEORY

Research has shown that 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, they will have the desire to reach this goal and 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 that happen while it takes place. Sometimes learners encounter events that increase their motivation to reach a goal, so the student gets closer to achieving their goal. However, learners can also encounter situations that cause a decline in motivation, and taking them further away from their goal. This study aims to assess what factors in to student motivations to become an Industrial Engineer at two different levels of education, middle school and undergraduate studies. Studying the motivation of the students at varying levels is important due to the dynamic nature of motivation. It is important that students become interested and remain motivated throughout the duration of their education. At the undergraduate level, they study will be two fold. First, we will study if on average different populations of industrial engineering students have different motivation levels. Secondly, we will study how students describe their motivation. At the middle school level, we will test the effectiveness of industrial engineering modules added to a pre-engineering curriculum to increase the general student motivation to become an industrial engineer. Although the two studies are different, the VIE Theory of Motivation is useful in answering all of the research questions.

Literature Review

According to The VIE Theory of Motivation, motivation is a function of three perceptions, Valence, Instrumentality, and Valence (Vroom 1964). The motivation is a product of the three factors, or

$$\mathbf{M_{b \rightarrow g} = V*I*E.}$$

The equation can be interpreted to mean that all behaviors are inspired by a goal that will be reached if the behavior is effectively completed. As the values of the individual components increase, the motivation to perform the behavior increases. Increasing any one element will result in an increase in motivation. The multiplication signs indicate that all 3 components must be present for motivation to exist. If a term is negative, avoidance of the activity exists, rather than motivation.

Valence is the value the individual personally places on the actions and rewards. This is a function of his or her needs, goals, and values. Valence is comprised of two additive components,

$$\mathbf{V = V_g + V_b,}$$

where V_g denotes Value of the Goal and V_b denotes Value of the Behavior. This simply means that value can come from participating in the activity or the goal the activity will yield. Value of the Behavior measures intrinsic characteristics of the activity. Their additive property is important for several reasons. As a method of increasing motivation to complete a behavior, you may add additional goals that the behavior will accomplish.

As you add additional goals, their values are added together to increase the valance. Also, only one of the components, either V_g or V_b must have a positive valance for motivation to exist. For instance, a student could really detest a behavior, but value the outcome so highly they will participate in the behavior anyway to reach a goal. In this study, Valence measured how much the students valued sharing industrial engineering projects with the community (Value of the Behavior) as well as the value they place on the field of Industrial Engineering (Value of the Goal).

Instrumentality is the belief based on the perceived performance-goal relationship that if one does complete the behavior, he or she will reach their goal. Instrumentality is a measure of the behavior's utility, or usefulness to achieving goals. It is the learner's perception that completing the behavior will increase the probability of accomplishing a future goal (Husman, et al. 2004). "When tasks are perceived to be instrumental to personally valued future goals, their incentive value is enhanced through future goals to which they are connected. It is the incentive value that give the tasks meaning," (Green, et al. 2004). Instrumentality increases motivation and contributes to the use of effective learning strategies and increased school performance (Simons, Dewitte and Lens 2004) (Andriessen, Phalet and Lens 2006) (Phalet, Andriessen and Lens 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, Phalet and Lens 2006) (Phalet, Andriessen and Lens 2004). In Belgium, it was proved students who are highly motivated attach the highest instrumental value to their schoolwork (Lens and Decruyenaere 1991). Instrumentality is similar to Bandura's

Outcome Expectancy, or a person's estimate that a given behavior will lead to certain outcomes (Bandura 1977).

Researchers study instrumentality as a function of several different variables. One useful distinction is based on the focus of the goal. Exogenous instrumentality is the utility value associated with completing necessary steps to achieving your long-term goal, but is not helpful to your ultimate goal. Endogenous instrumentality is the utility value associated with a task that directly relates to the future goal (Husman and Lens 1999). Other researchers identified multiple types of instrumentality by characterizing different dimensions that affect it. In some cases, the goal-behavior relationship and regulation, or the reason for participating in the behavior, create three types of instrumentality: extrinsic motivation and externally regulated, intrinsic motivation and internal regulation, and extrinsically motivated and internally regulated. When students are externally regulated, they are motivated by grades, rewards, status, and reputation, while internally regulated students are concerned with personal or professional development or broadening their horizons and their reasons for participating in the behavior originate inside them. When a student is intrinsically motivated, they find value inherently in the task. Extrinsically motivated individuals are concerned with the benefits to the individual. The different types of instrumentality affected goal orientation differently, but goal orientation accompanying extrinsically motivated and internally regulated instrumentality is very similar to the goal orientation associated with intrinsic motivation and internally regulated instrumentality (Simons, Dewitte and Lens 2000). These two types of instrumentality are preferred over extrinsically motivated and externally regulated instrumentality because they influence the adoption of mastery goals (Green, et al. 2004) (Simons, Dewitte and Lens 2000). To encourage extrinsically motivated and internally regulated instrumentality, stress that the task is applicable for one's personal or professional development (Simons, Dewitte and Lens 2000).

Similarly, the degree of utility was combined with type of regulation to create four different variations of instrumentality. The proximal utility is when a student emphasizes a behaviors' immediate or nearby goals and the distal utility emphasizes the behavior's future goals. The combinations yield proximal utility-external regulation, proximal utility-internal regulation, distal utility internal regulation, and distal utility and external regulation instrumentalities. To optimize motivation, educators should stress the combination of distal utility and internal regulation. Proximal utility and external regulation provide the lowest levels of motivation and performance (Simons, Dewitte and Lens 2004).

The importance of instrumentality is often ignored in current motivation research, but evidence exists supporting its significance. In fact, perceived instrumentality can positively predict school performances (Malka and Covington 2005) and work ethic (Phalet, Andriessen and Lens 2004). Endogenous instrumentality has been proven a unique variable that is weakly related to task utility. If it is not included in motivation research, the future oriented items are unaccounted for (Husman, et al. 2004). Perceived instrumentality has been proven empirically distinct from task value, self-efficacy, and the four goals from the 2 by 2 achievement goal model, performance-approach, performance avoidance, mastery approach, and mastery avoidance for college students.

In fact, perceived instrumentality predicts graded performance in college courses (Malka and Covington 2005). Variations in perceived instrumentality influence the use of meaningful strategies, mastery goals, and performance approach goals. (Green, et al. 2004). Both minority and non-minority students' motivation is increased by positive perceived instrumentality and internal regulation by future goals (Andriessen, Phalet and Lens 2006).

Expectancy is the probability based on the perceived effort-performance relationship that one's effort will lead to the desired performance and is based on experience, self-confidence, and the perceived difficulty of the performance goal. It measures how likely a person believes they are to be successful at a behavior. A person must have adequate knowledge, skills, and resources to complete an activity.

The seminal paper in self-efficacy is Bandura's "Self Efficacy: Toward a Unifying Theory of Behavioral Change" (Bandura 1977). In this work, he first distinguishes outcome expectations and efficacy expectations. While outcome expectancies are similar to instrumentality as mentioned above, an efficacy expectation is the conviction that one can successfully execute the behavior required to produce outcomes. Expectations of successful completion of a task affects whether or not an individual will initiate and continue a behavior. Their opinion of their ability determines how many difficulties they are willing to try to overcome. There are three dimensions of self-efficacy: magnitude, generality, and strength.

Efficacy expectations can be induced from four sources: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal.

Performance accomplishments result from personal mastery experiences, and this makes them especially significant. Successes raise mastery expectations whereas failures lower them. Performance accomplishments include participant modeling, performance desensitization, performance exposure, and self-instructed performance. Vicarious persuasion is based on social comparisons: seeing others perform threatening activities without poor outcomes increase expectations because observes think they too might be able to improve if they continue to participate in the behavior. Vicarious persuasion can take the form of live modeling and symbolic modeling. Verbal persuasion is an easy and readily available mean to increase efficacy. Suggestions, exhortation, self-instruction, and interpretive treatments are a few types of verbal persuasion. Emotional arousal can also impact efficacy because challenging situations arouse emotions, and this factors into an individual's judgment of their abilities. Attribution, relaxation, biofeedback, symbolic desensitization, and symbolic exposure are a few examples of emotional arousal. "People process, weigh, and integrate diverse sources of information concerning their capability, and they regulate their choice of behavior and effort expenditure accordingly," (Bandura 1977).

Self-efficacy has recently been applied to the field of engineering education. Hutchison and her research team identified 9 factors that students thought affected their self efficacy. Eight of the nine factors mapped back to one of Bandura's four sources for efficacy expectations. Understanding and learning, problem-solving abilities, training, computing abilities, and working assignments are all sources of performance accomplishments. Vicarious experiences and social persuasion were both discussed in the themes teaming and seeking help. Enjoyment, interest, and satisfaction are considered emotional arousal. Drive and motivation was the only theme the research team could not fit into one of the four sources (Hutchison, et al. 2006).

Although this research team is based on the VIE theory, many other theories of motivation exist in current literature. The modern Expectancy-Value theory explains achievement performance, persistence, choice based on expectancy, E, and task related beliefs, V (Eccles and Wigfield 2002). Subjective task value is comprised of 4 parts, interest-enjoyment value, attainment value, utility value, and relative cost. Many different factors contribute to these two constructs: Cultural Milieu, Child's Perceptions, Socializer's Beliefs and Behaviors, Stable Child Characteristics, Previous Achievement Related Experiences, Child's Interpretations of Experience, Child's Affective Reactions and Memories, Child's Goal and General Self Schemata. Cultural Milieu encompasses gender and cultural stereotypes and family demographics. The child's perceptions are of socializer's beliefs, expectations, attitudes, and behaviors, gender roles, and activity stereotypes and task demands. Child's Goals and General Self Schemata include self-schemata, short and long-term goals, ideal self, and self-concept of one's abilities. Aptitude of child and siblings, child gender, and birth order all fit into the stable child (Eccles, et al. 1983).

The Future Time Perspective focuses on the idea that when participating in a behavior, an individual is motivated by goals. Goals can be sub-goals or final-goals and can vary in temporal distance, short or long (De Volder and Lens 1982). "FTP is defined as the present anticipation of future goals," (Simons, Vansteenkiste and Lens 2004). FTP has a cognitive and a dynamic aspect. The cognitive aspect tells us that people with an extended FTP have a higher instrumentality because the present behavior is helping them reach multiple immediate and future goals. The present task's value is greater for someone with a long-term FTP because of the greater value of the future goal (Simons, Vansteenkiste and Lens 2004).

Why VIE Theory?

Although other theories have been more prevalent recently, the VIE theory was chosen for numerous reasons. Instrumentality is valued in the research questions being posed, and deserved treatment as its own construct. Others researchers agree. "Trying to convince students to adopt mastery goals when they lack interest in the task and cannot see its utility for the future is a hopeless venture," (Green, et al. 2004). This is partially based on the nature of engineering education. 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. Green and her team had a similar thought: "There are many situations in the course of one's academic career in which the need to master the material is driven not by an enjoyment of gaining the new knowledge or an abstract want to improve one's knowledge and skill, but rather the realization that knowledge will be needed in the future," (Green, et al. 2004). Other researchers have realized the importance of the future focus as well. Husman et al. stated, "There is no question that students' aspirations- their hopes and expectations for their futures – are important to them; they should be important, if not central, to the study of achievement motivation," (Husman, et al. 2004). The VIE theory measured four very important constructs to engineering students' motivation (Value of the Behavior, Value of the Goal, Instrumentality, and Expectancy).

CHAPTER TWO

A MIXED-METHODS APPROACH FOR INSIGHT ON STUDENT MOTIVATION TO BECOME A SUCCESSFUL INDUSTRIAL ENGINEER

A person's experiences and demographics are a few factors that could affect his or her motivation. This study particularly looks at the behavior of participating in authentic learning activities to reach the goal of becoming a successful Industrial Engineer. We aim to assess motivation differences between different subsets of Industrial Engineering students in their journey to become an Industrial Engineer. The compared groups are males and females, students who participate in university sponsored authentic learning experiences and those who have not, including both upperclassman and underclassman.

This sequential explanatory mixed methods study intends to gain insight into what motivates students to become a successful industrial engineer. The quantitative methods will focus on authentic learning programs and their benefits. The qualitative methods will allow us to further explore the results from the quantitative results, but will not be restricted to the context of authentic learning programs.

Context

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 or discipline. Authentic learning activities often increase student motivation because they are meaningful to the life of the student and connect education to real life events. They are able to engage students in the learning. Authentic learning activities prepare students for their futures. Often learning is student driven with teachers, employers, and experts assisting and coaching the learning process (Lombardi 2007). This paper will focus on two university sponsored authentic learning activities, Creative Inquiry (CI) and Cooperative Education (Co-op).

Creative Inquiry is an undergraduate 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. In the department the participants are enrolled in students can use up to 6 hours of CI credits as "Technical Elective" requirements.

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 that does not count toward degree progress but count toward their Cooperative Education Certificate.

Literature Review

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 accomplish all of the outcomes intended. The engineering workplace was ranked highest as the best setting to develop and demonstrate work place competencies by employers, engineering faculty and staff, administrators, alumni in a study by Brumm, Hanneman, and Mickelson (Brumm, Hanneman and Mickelson 2006). Co-oping provides many academic and job related benefits to participating students. Students who co-op tend to have higher GPA's and starting salaries then students who do not (Gardner, Nixon and Motschenbacker 1992) (Lindenmeyer 1967) (Blair, Millea and Hammer 2004) (Fletcher 1989). The Quantity of Co-op correlates positively with starting salary after college (Gardner, Nixon and Motschenbacker 1992) (Blair, Millea and Hammer 2004). Students who co-op find jobs faster and obtain promotions and advancements faster once employed than students who do not co-op (Wessels and Pumphrey 1996) (Fletcher 1989). Co-oping provides students with many personal gains. Students are able to gain a realistic expectation of the real world (Fletcher 1989). Co-op students often have increased "soft skills" that are deemed critical for industry success including communication and teamwork skills (Gardner, Nixon and Motschenbacker 1992). Coops allow students to grow and increase their self-confidence, responsibility and maturity (Cates and Jones 1999) (Gardner, Nixon and Motschenbacker 1992).

Over the past 2 decades, the National Science Foundation has been advocating Research Experience for Undergraduates. However, most NSF REU's are much different then Clemson University's Creative Inquiry. There are two types of experiences funded by the NSF. One is typically eight to ten week summer experiences and the other is to involve a single undergraduate to participate in ongoing work on an NSF sponsored grant (Pierrakos and Trenor 2009). These types of studies dominate the literature related to undergraduate research experiences, so it is also the focus of our literature review. These studies do not account for the additional benefits that could be seen from participating in research during the normal academic year at a student's home university. REU's are expected to be an intellectual-experiential process (Hunter, Laursen and Seymour 2006). Researchers agree that research experiences for undergraduates are beneficial for participating students, especially students who are truly interested in the research topic. In addition to increased research skills, productivity, and interest (Kremer and Bringle 1990) undergraduate research experiences afford personal and professional growth and development, self understanding, and allows students to find themselves as a young scientist (Hunter, Laursen and Seymour 2006) (Seymour, et al. 2004). Research experiences increase undergraduates' understanding, confidence, and self-awareness (Russell, Hancock and McCullough 2007) (Russell, et al. 2005) (Seymour, et al. 2004). Students are able to make connections between bodies of knowledge, apply their prior knowledge and reflect on their thinking (Seymour, et al. 2004)). Additionally, participants increase their oral communication skills, or their abilities to present, discuss, and defend their work (Kardash 2000) (Seymour, et al. 2004). These experiences allow undergraduates to become part of community of practice which affects their careers (Seymour, et al. 2004). REU's help clarify student interest in stem careers (Russell, Hancock and McCullough 2007) (Russell, et al. 2005). REU participants are accepted to higher education programs faster than no participants (Kremer and Bringle 1990). In fact, REU's increase anticipation of higher education degrees or research as a career choice (Russell, Hancock and McCullough 2007) (Russell, et al. 2005) (Kremer and Bringle 1990) (Seymour, et al. 2004).

The previous studies take into account learning outcomes, GPR's, and salaries, but not what allows students to be able to achieve these things: *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 so they make a positive impact on students, and produce high achieving, engaged students.

Quantitative Methodology

This cross sectional study takes a snap shot of student motivation at the time of this study took place The study is interested in three variables: Project Experience, Gender, and Class Standing. Students with university sponsored authentic learning activities will be compared to students who have not participated in the University Programs. Some students who are considered to be without experience will have participated in some type of summer internship or career-related employment. However, the university does not regulate the student's summer experiences in anyway, so there was no way for the researchers to know if the job provided an authentic and meaningful experience.

The Survey

A survey was constructed based on VIE Theory and can be seen in Appendix A. In order to gain information about the variables of interest, demographic information was collected through open-ended questions. The demographic information included gender, race, class year, and project experience. We left the project experience open-ended to gain insight as to what the students thought could be considered. The survey consisted of 24 statements with Likert scale responses, to which values of one through five corresponded to strongly disagree, disagree, neutral, agree, and strongly agree, respectively. The responses were then recoded on a scale from -2 to 2, so that 0 would represent a neutral response. The research team mapped statements to one of the four VIE constructs, which can be seen in Table 1. The specific questions that 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. The reliability analysis can also be seen in Table 1.

Table 2.1: 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	*How much do the students value the process of sharing Industrial Engineering ideas and projects with the community?*	.49 to .75	.68
Value of the Goal	*How much do the students value the benefits of Industrial Engineering?*	.44 to .82	.71
Instrumentality	*If a student shares Industrial Engineering concepts outside of the university setting will they think the profession is more beneficial?*	.41 to .78	.70
Expectancy	*After working with the Industrial Engineering ideas outside of the college setting, do they think they can successfully be an industrial engineer?*	.46 to .74	.62

Students enrolled in the Clemson University Industrial Engineering program were invited to participate in the study. Between December 2008 and March 2009, 51 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 28 students who had participated in some type of university sponsored authentic learning activities and 23 who had not. The division among grade level yielded 27 seniors and 24 underclassmen. When separating the population due to gender, they study had 24 females and 27 males.

Since the sample size of our categories is small, a non-parametric statistical analysis was needed. These tests do not assume normality, so no tests are required to determine if the data follows a normal distribution. If a result is significant using a non-parametric test, it is always significant using a parametric test. Non-parametric statistics are commonly used to analyze data generated by a Likert scale. The Mann Whitney test is the non-parametric equivalent to the t-test, which detects differences between means 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 Error (Walpole, Myers and Myers 2007).

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 and it is much more of a reality for them. Many of the seniors who completed the survey had already been offered a job or were seriously looking for one. The seniors were very close to receiving a degree in IE. Statistical difference was observed between class grades. Upperclassman who have completed more credit hours have a higher motivation due to their value of the goal. Seniors value the benefits and significance of Industrial Engineering more than sophomores and juniors. This provides Criterion Validity for the survey.

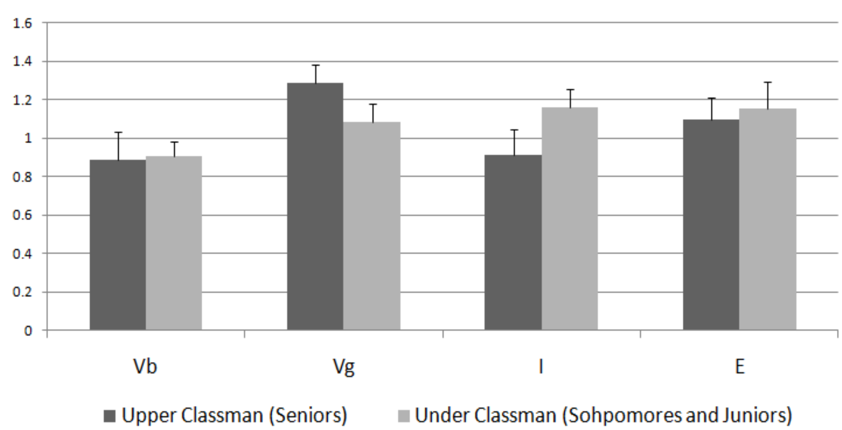

Figure 2.1: Motivation Construct Comparisons by Class Standings: This figure depicts how students at different levels answered questions about the VIE constructs. The values depict the averages for upperclassmen and underclassmen. Statistically, value of the goal is different.

Quantitative Results

A major result is the key differences between male and female students' motivation. Female students have higher motivations to become an Industrial Engineer than male students do. Their motivation is proven statistically higher in two areas, Value of the Behavior and Instrumentality.

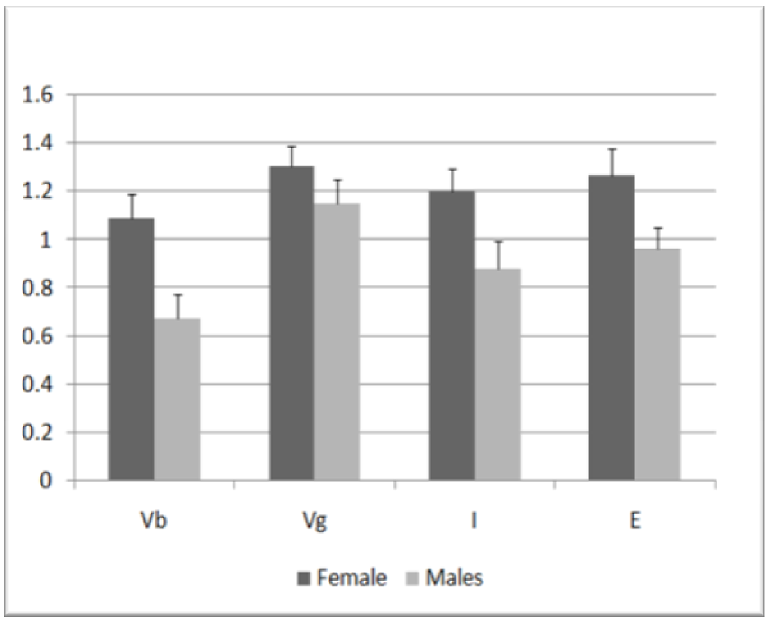

Figure 2.2: Motivation Construct Comparisons by Gender: This figure depicts how male and female answered survey questions about the VIE constructs. The values depict the averages for all questions that relate to the construct. Statistically, value of the behavior and instrumentality are different.

Another key result is the difference between students who have participated in university sponsored authentic learning programs and those who have not. Students who have participated in the programs have a higher motivation than others do. Statistically, the students who have participated have a higher expectancy than students who have not. This means that students who participate in these programs are more confident that they have the knowledge, skills, and resources to successfully become an industrial engineer.

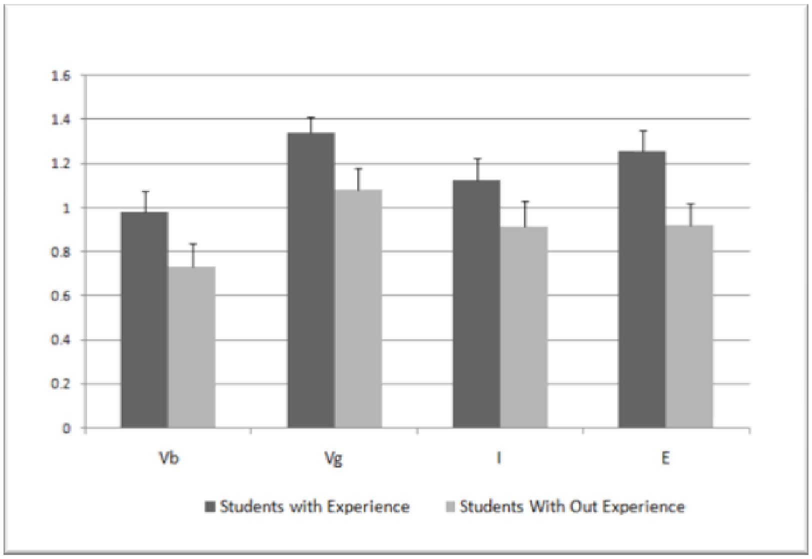

Figure 2.3: Motivation Construct Comparisons by Project Experience: This figure depicts how students with university project based experience and students without university sponsored project experience answered survey about each of the VIE constructs. The values depict the averages for all questions that relate to the construct. Statistically, the expectancy is higher for students with the experiences.

Discussion

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 do. The female students like experiential learning programs more than males do. They enjoy them and find them interesting. They have high intrinsic feelings about the programs they have participated in. The instrumentality difference suggests that female students believe participating in experiential learning projects directly relates to them becoming successful industrial engineers. They perceive the programs have a high utility to help them reach their ultimate goal of becoming successful in the field of Industrial Engineering. The literature provides support for the difference observed in Value of the Behavior. Generally, females' motivations and reasons for choices are more altruistic than males. The goals women rank higher are the desire to work at something they care about which often includes social causes (Seymour and Hewitt 1997). It is common for women tend to prefer dealing with people while men are more interested in dealing with things (Pressley and McCormick 1995). The support for the results from the survey further validates our survey instrument.

Based on the survey responses, the students who have participated have a higher expectancy than students who have not. In other words, students who participate in these programs are more confident that they have the knowledge, skills, and resources to successfully become an industrial engineer.

Qualitative Methodology

Data Collection

All students from the Industrial Engineering 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 authentic learning programs. The class-standing breakdown is two seniors, five juniors, and one sophomore. To protect student confidentiality, each participant was given a pseudonym, and these can be seen along with the variables of interest in Table 2.2.

Table 2.2: Participant Descriptions

Name	Gender	University Sponsored Project Experience?	Class Year
Amber	Female	No	Junior
Ashley	Female	Yes	Senior
Billy	Male	Yes	Junior
Hannah	Female	Yes	Sophomore
Jackson	Male	Yes	Junior
Lily	Female	Yes	Senior
Oliver	Male	No	Junior
Roxie	Female	No	Junior

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. The questions in the protocol were open-ended and designed to explore the research question through the lens of the theoretical framework. Since the researchers designed the interview protocol to not be leading, they did not specify for the students to answer in the context of the previous quantitative study. That is, the participants' responses were not limited to the specific behavior of participating in authentic learning activities. Content Validity was established for the interview protocol (DeVellis 2003). An expert in qualitative research reviewed the interview protocol and made sure that the questions were appropriate, unambiguous, and was asking the questions we wished to answer. The corrections were included in the protocol before the surveys started. The participants' experiences were captured from their perspective and documented using an MP3 recorder with their permission and professionally transcribed.

Experience of Research Team

Drs. Maria Mayorga and Lisa Benson are both faculty mentors in the Creative Inquiry Program who have initiated a variety of projects. Dr. Mayorga's projects have focused on the fields of Industrial Engineering and Engineering Education. Within Industrial Engineering, her students have worked on Operations Research projects in Health Care, Manufacturing, and the Service Industry. In Engineering Education, Dr. Mayorga's students worked on teaching IE concepts to Middle School students and utilized quantitative and qualitative tools. Dr. Benson's projects have focused on Interdisciplinary Design Projects and Engineering Education. Her design projects have been a part of the Disney Design Challenge. Her Engineering Education projects engage upper level engineering students in the development of design projects for first year students and the effects of motivation on learning.

Danielle Lanigan has had ideal participatory experiences in both the Creative Inquiry and Co-op programs. As an undergraduate student, she was able to work on two different projects in the CI program and complete six credit hours. She worked with one other student and Dr. Maria Mayorga on both. Both projects focused on using Operations Research tools to solve real world problems. The first project took place in the service industry, and the second took place in a manufacturing setting. The two projects yielded two conference presentations and one conference proceedings paper. Each project received an award in the Industrial Engineering Research Poster Competition. As a graduate student, Danielle mentored a team of five undergraduate students who also worked with Maria Mayorga. The team worked on the engineering education project that involved teaching Industrial Engineering tools to middle school students. In the

Cooperative Education Program, Danielle was successfully employed at Ethicon, Inc, A Johnson and Johnson Company. She completed 5 semesters work experience to complete her Cooperative Education Certificate. Danielle alternated between two roles as the Industrial Engineering Co-op and Supply Chain Co-op. She received a Lean Practitioner training certificate while employed. She had very positive experiences in both programs.

Research Question

How do students describe what contributes to their motivation to become an Industrial Engineer?

Data Analysis

One researcher and one independent consultant coded the interview transcriptions. The researcher was familiar with VIE Theory of Motivation and the prior research in this study and the consultant was not. NVivo7, qualitative data analysis software, was used during the coding process. To start, an open coding approach was taken (Strauss and Corbin 1998). The coders both independently read the transcripts and identified important quotes but had little idea what the data was about. Eventually categories began to emerge and the coders each created their own list. In order to compare coding, an iterative inter-rated reliability check was used during the coding process. 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). Eight themes were identified during this phase. Each theme had a varying number of sub-themes that related to it; the total number of sub themes was 47, and their division can be seen in Table 3.

Table 2.3: Result of IRR Round 1 and Axial Coding

Theme	**Number of Sub-Themes in the Category**
Relationships	**5**
Nature of IE Field and Material	**7**
Goals	**9**
Personal Characteristics	**12**
Resources	**5**
Professional Identity	**4**
Altruism	**5**
Enjoyment	**0**

A master file was created and the coders recoded the interviews and started a second round of the inter-rater reliability check. Since many differences were still present, the team reconciled the differences and further clarified the themes. After round 2, the 8 themes remained, but 51 sub-themes were identified.

Table 2.4: IRR Round 2 Results

Theme	Number of Sub-Themes in the Category
Relationships	5
Nature of IE Field and Material	8
Goals	10
Personal Characteristics	14
Resources	8
Professional Identity	2
Altruism	4
Enjoyment	0

The third round of the reliability check yielded a final inter-rater agreement of 100% and eight emergent themes, and 51 sub-categories, with no change from the second round. The eight emergent themes are Altruism, Enjoyment, Goals, Nature of IE Field and Material, Personal Characteristics, Professional Identity, Relationships, and Resources.

Qualitative Results

The eight prevalent themes (Altruism, Enjoyment, Goals, Nature of IE Field and Material, Personal Characteristics, Professional Identity, Relationships, and Resources) the students addressed when discussing what factors contribute to their motivation to become a successful Industrial Engineer are defined in this section. A more detailed discussion is provided in the next section. To support the emergent themes and claims, we will 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*: Many students cited a desire to better the world. Students were concerned with several different areas that could help make the world a better place. While some students specifically stated what they are interested in, others just want to have an impact at some point in the future.

> "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)

> "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)

> "My motivation is to succeed at what I'm doing and also help someone else along the way." (Oliver)

II. *Enjoyment*: Many students listed their 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 get to work on. Students intrinsically value the things that they are doing.

> "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)

> "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:* Students listed the goals that they set as well as the goals that others have set for them as one of the drivers of their motivation. The goals varied among participants. Some,are focused on salary.

> "Getting a salary, getting money, being able to move somewhere where I want to live." (Jackson)

Some focused on more immediate goals like making good grades and graduation.

> "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)

> "So in the academic realm I guess motivation comes from just maintaining a good GPA to get a job after college." (Billy)

Others focused on making a contribution to a larger body.

> "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:* Many students are motivated to become a successful engineer due to the characteristics that are inherent to the subject. Not only did they list the field as interesting, they also discussed its versatility.

> "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)
>
> "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)
>
> "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)
>
> 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)

Participants discussed Industrial Engineering's benefits, applications, and even acknowledged useful topics.

> "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)

> "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)"

Finally, many of the students discussed how they liked that the field allowed them to work directly with people.

> "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)

> "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*: Participants discussed many character traits that are necessary to become a successful Industrial Engineer. They agreed that some technical abilities are necessary, including intelligence and problem solving and analysis capabilities.

> "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)

> "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)

Students also discussed the importance of being well-rounded and having a good grasp of soft skills, like communication, creativity, leadership, and organizational skills.

> "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)

> "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)

> "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)

The students discussed how their interest in the material, effort, drive, and persistence factored into their motivation

> "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

> 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*: This theme has to do with how the participants thought others viewed the field of Industrial Engineering and what they could do to improve it. Many students were concerned about the uninformed views of others.

> "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)

> “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)

The participants were very concerned with improving other’s knowledge about industrial engineering. Most agree it is important to share their abilities to show the usefulness of the profession.

> “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)

> “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:* Many of the students in the study said 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.

> “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)

> “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)

> “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)

> “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)

> “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: The participants in this study realized the importance of utilizing your resources to be successful one day. Resources come in all forms: time, money, and people. The students considered their friends, TA’s, 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.

> “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)

> “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)”

> “And my dad’s an engineer and so, actually the other day I had a question about lean manufacturing and kanban 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)

Since several of the themes were mentioned multiple times, the researchers thought it would be important to measure the percent of the total references a theme received, the breakdown of the most prevalent themes, and the percent of students that mentioned each theme. Figure 2.4 shows the percentages based on the frequencies of responses.

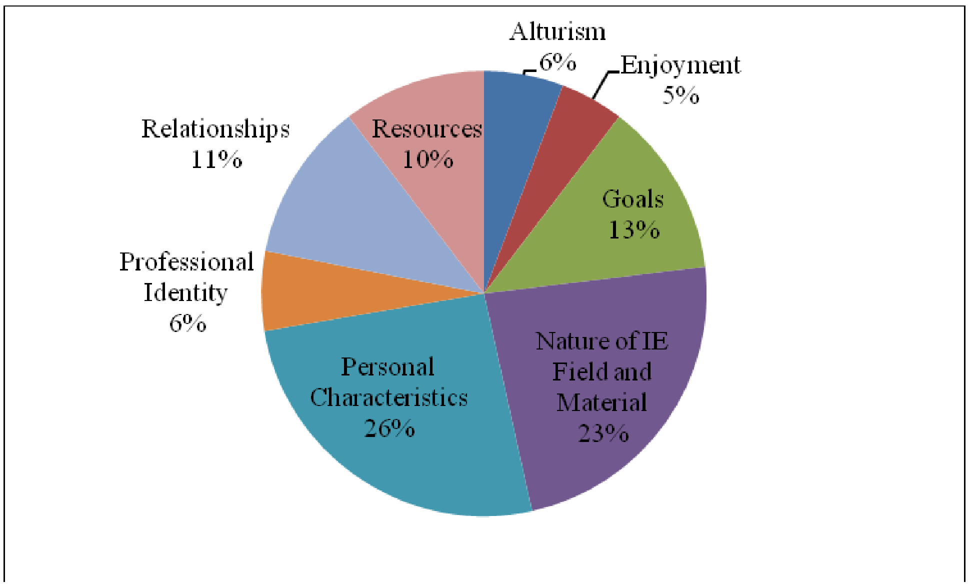

Figure 2.4: *Distribution of Coded Responses*: This figure shows how the coded responses are broken up into the 8 themes.

Personal characteristics made up 26% of the coded responses. The breakdown of personal characteristics can be seen in Figure 2.5. Within this theme, 21% of these comments fit into the stub-theme of effort drive and persistence, 16% of the comments were about intelligence, and 12% of the remarks were about the need to be truly interested in the material.

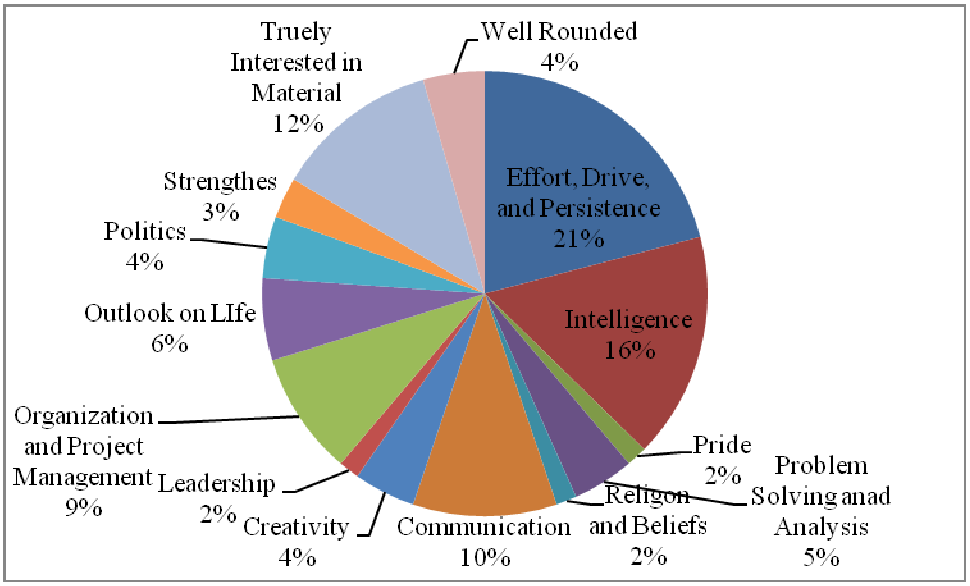

Figure 2.5: Distribution of Codes within Personal Characteristics Theme: This pie chart depicts the breakdown of the Personal Characteristic theme into sub-themes.

The Nature of IE material and field made up 23% of the coded responses. The breakdown of the subcategories within this theme reveals that versatility makes up 43% of the responses coded in this theme, which equates to 10.1% of the total coded responses. This is by far the most discussed sub-theme. Other noteworthy subthemes in this category include the field's application and the opportunity to work with people.

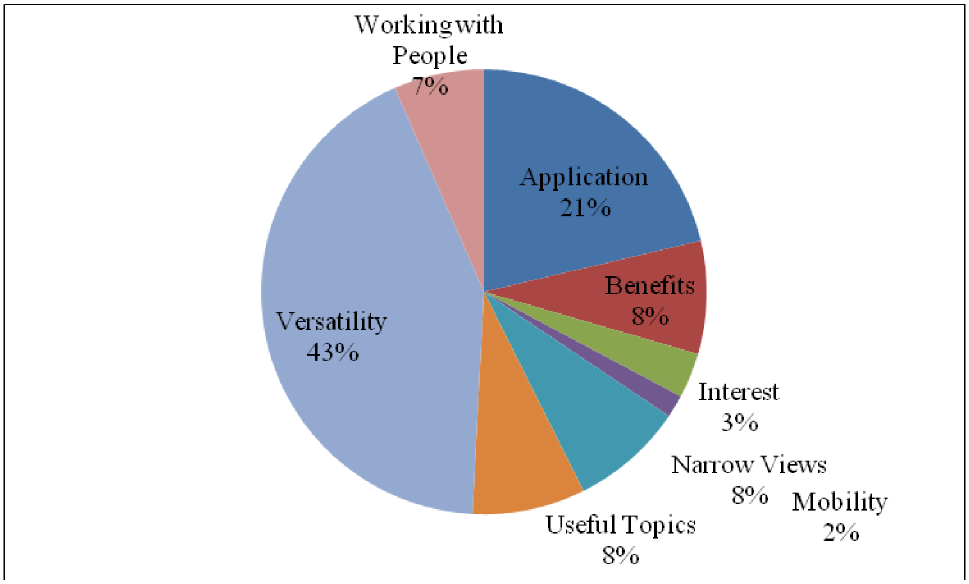

Figure 2.6: *Distribution of Coded Responses within Nature of IE Field and Material:* This figure illustrates the division of the Nature of the IE Field and Material theme into sub-themes.

Nineteen sub-categories were mentioned by greater than 50% of the participants.

This can be seen in Figure 2.7

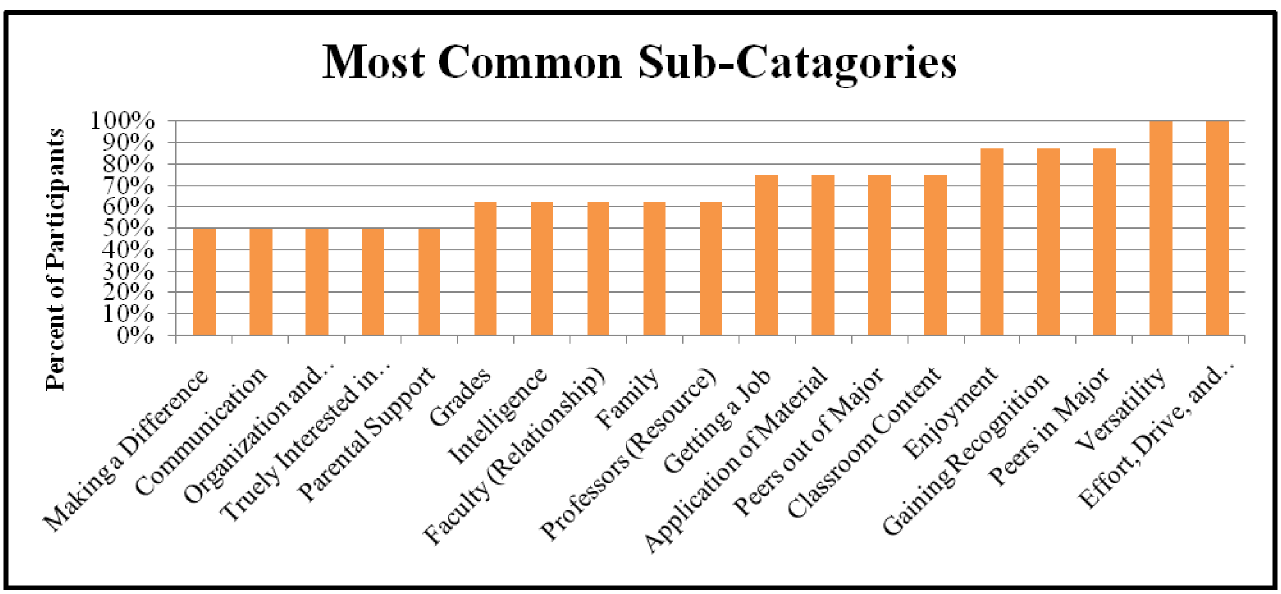

Figure 2.7: Most Common Sub-Categories: These topics were mentioned by the majority of the participants that participated in the qualitative portion of this study.

Discussion

Relation of Themes to VIE Constructs

The themes that emerged from the student's interviews can be categorized into the 4 constructs of the VIE Theory of Motivation, Value of the Behavior, Value of the Goal, Instrumentality, and Expectancy. Some of the emergent themes can fit into more than one of the construct categories because of the way the participants discussed them in the interview. The relationship between the emergent themes and the four constructs can be seen in Table 2.5. The factors that positively influenced student motivation will be the focus of this section.

Theme	V_b (experience of being a student)	V_g (Being an IE)	I (what they are doing as a student will help be an IE)	E (I will be successful)
Relationships	Faculty Peers Teamwork	Peers Outside Family		
Nature of IE Field and Material	Working With People Applications Mobility Versatility	Working with people Benefits Applications Versatility Interest	Application Useful Topics Narrow Views	Narrow Views
Goals	Contribution Recognition	Contribution Recognition Getting a Job Life Style and Money	Grades Graduation Recognition	Task Completion
Personal Characteristics	Outlook on Life Interest in Material Well Rounded	Pride		Effort, Drive, Persistence Intelligence Problem Solving and Analysis Skills Religion and Beliefs Communication Creativity Leadership Organization and Project Management Skills Personality Strengths
Resources				Classroom Content Co Workers Help People in other Fields Professors Time Parental Support TA's Authentic Learning Programs
Professional Identity		View of Field Gaining Field Recognition	Gaining Field Recognition	
Altruism		Bettering Environment Making an Impact Helping People Motivating Others		
Enjoyment	Enjoyment			

I. *Value of the Behavior*: The emergent themes that students discussed that could increase their value of the behavior are Relationships, Nature of IE Field and Material, Goals, Personal Characteristics, and Enjoyment. These themes all address the students' satisfactions in their experiences as a student. They can all increase a student's intrinsic feelings about the behavior. Healthy relationships can greatly impact a students' experience in school. 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 Industrial Engineering field itself. Students like that the field is applicable, mobile, and versatile. Students also appreciate it is an engineering field that will allow them to work with people one day. Students also value the behavior because they value reaching lower level goals on the way to their ultimate long-term goals. Lower level goals include recognition and contributions for successful completion of school work. Knowing there will be incentives along the way helps students attach importance to the behavior. Many personal characteristics and personality traits will help increase student's value of the behavior. If a student has a positive outlook on life, is truly interested in the material, and is well rounded, they will enjoy being a student more.

II. *Value of the Goal*: Students discussed the factors of Altruism, Personal Characteristics, Goals, the Nature of the IE Field, and Relationships that could have an impact on how much they value the goal of becoming an Industrial Engineer. Many students attach great importance to the fact that the field of Industrial Engineering will allow them to make an impact on the world. Students are specifically interested in helping and motivating others, and improving the environment. The belief that industrial engineering will help them do this increases how much they value becoming a successful IE one day. Another way to show how much students value the goal is whether or not they discuss a sense of pride they have with the material. If they are proud to complete the work now, they will value being an Industrial Engineer one day. Many students discussed alternate goals they strive to reach one day that becoming an IE can help them with. Students highly value getting a job that will allow them to make a good salary and live an adequate life style. They also value being recognized as successful and making contributions. The amount the students value these goals can be summed together to form V_g. The nature of the field and material also have a great impact on how much students value the goal. Students are particularly fond of the goal because it will allow them to work with people one day. They like that they can see how it is applicable, beneficial, versatile, and interesting. Relationships students have with others can also affect their value of the goal. Family and peers who are outside of the field's views often influence a student's view of themselves and what they are going to do in the future.

III. *Instrumentality*: A student must perceive what they are doing now as having a high utility to help them be an Industrial Engineer one day. The themes that fit into this category are Nature of IE Field and Material, Goals, and Professional Identity. Many students recognize that what they are learning really will help them one day through application of the material to a real world setting. They can identify topics that they have learned in class that could have an impact in a workplace setting.

Students are concerned about some lower-level goals that prove they find their school work instrumental for many different reasons. These goals are grades, graduation and recognition. Students also want to gain recognition for the field by sharing tools and concepts with others who are uninformed about the field. This demonstrates their beliefs in the usefulness of their experiences with industrial engineering as a student. Because the questions were designed not to be leading, this construct was a little harder to -document, but many students alluded to it. We will also provide anecdotal evidence for this construct.

> "Just seeing how practical and how useful it is. It's not something that you can just, you just learn, and you put your textbook on the shelf." (Oliver)

> "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)

> "I think if everybody has like a basic knowledge of some IE things then you know, we can all benefit from it, even if it's as small as like changing one little thing you do to affect your household or changing one little thing to affect, you know, your homework assignments or group projects like even if you're not an IE you can still benefit from that." (Hannah)

IV. *Expectancy*: To be motivated to be an IE, students must think they have the capabilities to be successful in the future. Participants in this study discussed many variables that they think they need to be successful. Goals, personal characteristics, and resources are the emergent themes that fit into this category. A goal often stated by students is task completion. As students accomplish more tasks, and increasingly harder tasks, their expectancy will increase. Students were very specific when discussing what personal characteristics are needed to be a successful IE, and they included effort, drive and persistence, intelligence, problem solving and analysis, religion and beliefs, communication skills, creativity, leadership, and organization and project management skills. Students also thought that to be successful as an IE it would be helpful if your personality strengths matched the strengths of the major. An important part of expectancy is thinking that you have the resources to be successful. Students listed numerous resources that would help them in the future: classroom content, authentic learning experience knowledge, time, and help from other people. Students listed co-workers, professors, teaching assistants, parents, and experts in other fields as people they could get help from.

Comparison of Quantitative and Qualitative Results

Although the quantitative results showed that all the students in this study had positive motivations, they did shed light on some differences in motivations between different populations. The qualitative results were very similar, as all the students expressed that they have high motivations to be successful industrial engineers.

The quantitative results tell us that females have a higher value of the behavior than the male students do. The interview data supported this idea. The females in this study mentioned that in order to be motivated, you have to be truly interested in the material you are 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 subtheme was not mentioned by any of the male participants.

Our quantitative results showed that the females have a higher instrumentality than males. This was not supported by our qualitative interview data. The quantitative results also state that students who have project experience have a higher expectancy than males do. These differences were not observed in our qualitative data. This could possibly be a result due to the voluntary nature of participant recruitment. The type of student who takes the extra time to participate in the interview process are more highly motivated than students who committed to only taking the survey. In future research, the incentives for participating in the interview process should be higher to allure some students with lower motivation.

Motivation Detractors

As mentioned previously, most of the data was similar to the quantitative data in that all the participants were positively motivated to be an Industrial Engineer. Only a few things were brought to our attention as motivation detractors.

One student discussed how class relevance factored into her motivation. If she could see how a class related to her degree, she was willing to work harder at it. This has a huge impact on a student's instrumentality.

> "A lot of the [] courses [history, political science previously mentioned] I'm now taking now I don't see like the benefit they're going to have like directly to industrial engineering so I guess my motivation in those classes are less but the motivation like with courses that directly relate to my major and like the degree I want to get [are higher]." (Ashley)

Another interesting phenomenon that the interview data brought to our attention is one of the students, Billy, who had work experience but had not participated in authentic learning activities had a very narrow view of what one could do within an IE career.

Billy attributed his decline in motivation to already having all the knowledge he needs to be successful on the job one day, despite only being an IE major for three semesters (Summer and Fall 2009 and Spring 2010).

> "In school I sort of lost some motivation because I sort of feel I have everything I need to go into the workplace so it's difficult to motivate myself to study for tests and you know, do coursework."

This student has a higher Expectancy to be a successful Industrial Engineer because he has placed severe limitations on the depth of the field. This could have possibly affected our quantitative data. This stresses the use of Mixed-Method approaches in Engineering Education. The quantitative data told us there was something going on, but without the follow-up interviews, we would have never known that on the job experience could be narrowing the student's views of Industrial Engineering.

Similarly, another student, Amber, listed very traditional IE tools as something she could never do in her career based on her experiences on the job and with her father.

> "The only thing that I've really seen that I didn't really agree a whole lot with is we had a class in production planning that actually Dr. [] teaches, but I mean, looking at [Company X], their IE's are not doing the production planning and they've got their mechanicals and they've got these other higher up people and actually we also had a class in facilities layout and design and talking to my father, he's like no, I would not put an IE out doing this. He's like that's our mechanicals' job and da-da-da and I was like, okay, so there's a few things that we're doing that we don't, that a lot of places aren't using, but even still it's good to see how it's used and you know, in case you are ever in that situation obviously" (Amber)

Her narrow views of an IE's capabilities have lowered her motivation due to a lack of instrumentality. Since she will never use the topics, she does not see a point in learning them. However, it is unfortunate she has constructed this view because production planning and facilities and layout design our powerful tools industrial engineers in the real world use.

Conclusions

Every student's motivation is different and depends on his or her personal characteristics and experiences. Quantitatively, female students have a higher value of the behavior, or they enjoy IE project work more than males do. Female students have a higher instrumentality, or they think participating in project work during school will help them be a better Industrial Engineer after graduation. Students who participate in university sponsored authentic learning activities have a higher expectancy, which means they think they have the ability to be a successful engineer one day.

Qualitatively, 8 emergent themes were identified that answer the question, "How do students describe what contributes to their motivation to become an Industrial Engineer?" They are Altruism, Enjoyment, Goals, Nature of IE Field and Material, Personal Characteristics, Professional Identity, Relationships, and Resources. These themes were able to fit in the VIE constructs and offer further insight into the perceptions of student motivations.

This study helps quantify the benefits of participation in university sponsored authentic learning programs in terms of student motivation. This paper also provides recommendations to increase motivation for individual students.

CHAPTER THREE

WARNING! ENGINEERS IN TRAINING: INTRODUCING MIDDLE SCHOOL STUDENTS TO INDUSTRIAL ENGINEERING, ITS USEFULNESS, AND ITS APPLICATION

Introduction

This chapter uses VIE theory in a different setting. It was the research team's first attempt at using the theory. They consider it a trial run on for the tools they used in the previously discussed study. A research team consisting of five Undergraduate Industrial engineering students from Clemson University taught the study participants, 120 students, ranging from 6th to 8th grade IE tools and concepts. The current curriculum of the pre-engineering program was based mostly on mechanical engineering concepts. Elementary and middle schools nationwide are beginning to incorporate the relatively new concept of an elective Pre-engineering course. The students in the pre-engineering class were recommended for the program by their teachers based on high performance in math and science. The purpose of this study was to explore the effectiveness of modules created by the team on middle school students' knowledge and attitude of industrial engineering. Additionally, the team sought to broaden the student's knowledge of industrial engineering, teach them and their teacher to manage their projects more effectively, and expand the scope of the material covered in class. Thus, by convincing the students of the value of industrial engineering and showing them that they had the ability to become an industrial engineer, students of all types would develop a greater interest in and be more motivated to pursue industrial engineering. In order to measure the students' attitudes and feelings regarding the subject, we employed quantitative research methods. The team chose to collect our quantitative data by distributing pre and post attitude surveys to all students currently in the pre-engineering program. In order to create and analyze the data gathered from these surveys.

Design

Each class period was made up of different grade level students (6^{th}, 7^{th}, or 8^{th} grade) and consisted of approximately 20 students. The team presented several modules over the course of the semester to each of the class periods. The team shared the tasks of developing concepts, creating module plans and activities, and communicating with the teacher between visits to the school. Some example lesson plans can be found in Appendix D. Every module was created to present a specific concept or teach about how to use a basic scheduling tool used in industrial engineering. In order to keep the students interested in the presentations, every day examples that middle school aged children can relate to were used. The team determined which concepts and tools to present to the middle school students by considering several factors. The team wanted the students to be able to apply what they learned to things they were accomplishing or involved in at that time. Initially, the team considered what projects they were working on in their pre-engineering class. The team tried to create modules that would expose them to tools they could use to be more successful in these projects. Then the team considered common industrial engineering concepts that could relate to situations the students may be interested in. In total, the team presented four modules over the course of the semester, covering the topics of Gantt Charts, Standard Work Instructions, Probability, and Decision Analysis.

Implementation

After the modules were created, the team went to the middle school and gave essentially the same lecture to six classes over two days. The pace of the presentation was altered so that all students of different grade levels could understand the technical content. Initially, the focus of our modules was on the presentation's content, rather than how the information was being presented; however, focus quickly changed as the team discovered that the students responded much better to hands-on activities and discussions rather than only a PowerPoint presentation. The team began to incorporate more activities and interactive means of teaching into their modules. After the first module, our formative assessment showed that the students responded much more favorably to the hands-on activities than presentations. In addition, the students paid more attention when given a worksheet to fill out during the presentation. An example of a worksheet given during a lesson can be found in Appendix E. Formative assessments were based on our observations of the lectures and suggestions from the teacher. These assessments were made while the research team was presenting the lectures. Particular things we observed were the students' willingness to participate in the activity and their enthusiasm towards the PowerPoint presentation. For each subsequent module, the team began with an attention-getting demonstration, followed it with a short presentation, and then spent the majority of the time on the activity. A fill in the blank worksheet that the students could follow along with accompanied the brief presentation. A detailed outline of each module was created to increase standardization among presenters. This also validated any data collected based on concepts and tools presented in our modules.

During the Gantt Chart lesson, the team showed the creation of a Gantt Chart to schedule the making of a bed. Then, the team asked the students to create their own Gantt charts for the making of a hamburger. For the Standard Work Instructions module, first the team asked the students to list the steps necessary to create an ice cream sundae. Then, their teacher followed their instructions word-for-word, to demonstrate the importance of being specific and preventing errors. The students really enjoyed seeing how missing small instructions could be comical: for example, forgetting to pick up the ice cream scoop and having to use your hands or putting the ice cream on the table instead of inside the bowl. Then, the students worked in teams to create their own work instructions to create a specific Lego shape. When they finished, they exchanged instructions and attempted to build the object described by another team. The Probability Lesson opened with an amusing video that presented a variety of circumstances in which you could use probability. Then, the students completed an activity in which they sorted a bag of M&Ms by color, and computed the probabilities of choosing a specific color. The results from the entire class were combined to show the overall average and to demonstrate that data is most valuable when numerous data points are collected. Finally, the team presented a lesson on decision analysis. The activity consisted of the students deciding between building a new stadium or a new dining hall at Clemson. The activity can be found in Appendix F. The students flipped a coin ten times, and the number of "heads" out of ten flips represented the probability of the

Tigers' having a winning season. The positive and negative outcomes of the decision were based on the Tigers' winning season, with the stadium being the riskier, but potentially more profitable outcome. The students enjoyed discussing the benefits and risks of both alternatives and relating decision analysis to something that is interesting and fun.

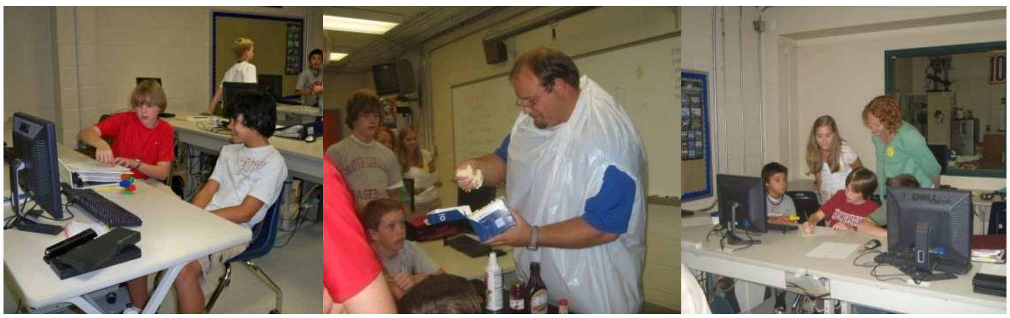

Figure 4.1: The students participating in the IE activities. The picture on the far left depicts students building lego structures with instructions prepared by other students in the class. The middle picture depicts the teacher, Mr. Billy Little, following exactly what steps students listed to make an ice cream sundae. The picture on the far right shows Clemson University students helping students write instructions so that other students may correctly build the lego structure they desire.

Assessment

A variety of tools such as surveys, observations and journals were used to measure the efficacy of these modules. Prior to the start of the modules, the team conducted a Survey based on the VIE Theory of Motivation to determine the student motivation toward Industrial Engineering. The survey was approved by the teacher, the principal, and the IRB in protocol IRB2008-340. The survey used can be found in Appendix G. The mapping of the survey questions to the VIE constructs can be found in Appendix H. In order to measure the motivation of middle school students to further explore and potentially pursue industrial engineering, an attitude survey was developed based on VIE motivation theory. The project team designed the survey to measure the students' motivation to pursue Industrial engineering throughout the remainder of their primary education and into college, eventually choosing it as a profession. The survey consisted of twenty-one statements, to which the students responded with a value of one through five, which corresponded to strongly disagree, disagree, neutral, agree, and strongly agree, respectively. These statements mapped to one of four constructs, which can be seen in Table 5. Each VIE construct was assessed, and each construct as well as the survey as a whole were evaluated for reliability. Overall construct reliability was measured using Coefficient α and the question/construct reliability was measured using Pearson's Coefficient of Correlation.

Table 4.1: Constructs used for Survey Mapping

Construct	Interpretation
Value of the Behavior	How much do the students value the Industrial engineering lessons added to their curriculum?
Value of the Goal	How much do the students value the Industrial engineering profession?
Instrumentality	If a student is successful in the engineering class will he be successful as an industrial engineer?
Expectancy	Do the students have enough knowledge about Industrial engineering to pursue if further?

Qualitative, or anecdotal, evidence was also collected. This was done in two ways. (1) The team made observations while teaching the module. They specifically observed the interactions between the students and the team, the students and the teacher and between the students themselves. (2) The team asked the teacher to keep a journal of his reactions and thoughts after the team presented each module. They wanted to know what the teacher felt about the implementation of the tools presented in the modules. An example of a comment given by the teacher in his journal is:

> "Today we did SWI's (standard work instructions). Students made the connection between SWI's and Gantt Charts although they are different tools, it is good to see them make associations with prior knowledge."

To improve the quality of the data gathered, the teacher was given prompts such as "What is going well?" "What isn't going well?," "Have you noticed any changes in your teaching methods," and "Have you noticed any changes in your classroom management techniques?" These questions helped to streamline his thoughts in the journal.

Results

Pearson's Coefficient of Correlation was used to determine if the questions on the attitude survey correctly measured the construct. Coefficient α was used to determine if the construct was reliable by looking at the average correlation of items within the test.

Coefficient α = N/ (N-1)*(Variance of Sums - Sum Item Variance)/(Variance of Sums), where N is the number of questions in the construct. For individual questions a Pearson Coefficient value of 0.4 or higher was acceptable. For the constructs, a coefficient α value of 0.6 or higher was acceptable (Benson and Switzer 2007). Valance items measured how much the students valued sharing Industrial engineering concepts with the community and how much the students valued the benefits of the profession of Industrial engineering. Because the Pearson Coefficient correlation of one of the statements ("I am a big-picture thinker") was well below 0.4, that statement was eliminated. This raised the overall construct coefficient α equal to 0.60, which is just high enough to be acceptable.

It was not surprising that the results for that statement were inconclusive, as many of the middle school students did not understand the meaning of the term "big-picture thinker," and had to have it explained to them.

The results of the Attitude Surveys are summarized in Table 6. The table shows the mean value reported in the survey presented before and after the project. The means of each statement in a construct were averaged together to get the mean value for the construct. All of the values in the table are on a scale from negative two to positive two. The surveys were on a scaled of one to five, but for coding purposes, three was subtracted from each response so that a neutral result would yield a 0.

Table 4.2: Results from Motivation Surveys

Construct	Pre Survey Mean	Post Survey Mean	Pre Survey Standard Deviation	Post Survey Standard Deviation	α Range	α Coeff-icient	Statistical Significance (p-value)
Value of the Behavior	0.98	0.91	0.45	0.61	.53 to .72	0.68	0.72
Value of the Goal	0.96	0.92	0.60	0.66	.50 to .69	0.67	0.53
Instrumentality	1.10	0.99	0.53	0.58	.54 to .77	0.75	0.13
Expectancy	0.85	0.71	0.55	0.63	.63 to .74	0.58	0.63
Sample Size	**58**	**102**					

Because the sample sizes were large enough to assume normality, we used an un-paired, two-sample t-test to analyze the results of the survey for statistical significance. The resulting p-values are shown in the last column of the table. A type 1 error value of 0.05 was used for analysis. Since all of the p-values were well over 0.05, the differences over the course of the study are not statistically significant.

Discussion

As shown in the table, all of the mean values for each of the constructs decreased over the course of the study. This is troubling, at first glance but the data is not statistically significant, so no differences can be assumed. We realized that when the students first completed the survey they had no prior knowledge of Industrial engineering. When filling out this type of survey without any background information of the subject material, the answers do not accurately portray the subject's motivation. We feel the original tests were higher because the students had no previous exposure to Industrial engineering. During our time at the middle school, we never really explained the roll of industrial engineers in society. The team feels the finding a specific definition of what an industrial engineer does would be very vague and hard to convey middle school students. Therefore, we mostly taught Industrial engineering tools and basic concepts.

Figure 4.2 shows the number of students that took the pre and post survey. Notice that the two sets are not the same because pre-surveys were inadvertently only administered to half of the classes while the post surveys were administered to most of the classes. Although this was not intentional, the teacher distributed the pre and post surveys on different days. The students alternate their schedules every other day, having "A" days and "B" days. The pre survey was given on one day and the teacher mistakenly gave the post survey to the classes on the other day. Not all of the pre-surveys matched the post surveys because absences and other unforeseen events.

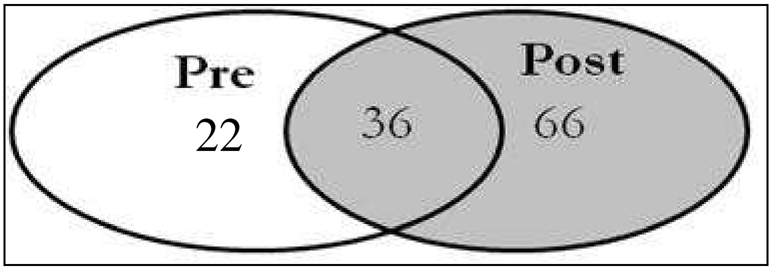

Figure 4.2: Students that Participated in Motivation Surveys: Due to circumstances outside of the students control, the pre and post surveys were not distributed to the same students. Only 36 students received both the pre and post survey.

We suspect that the results of the final survey may have been adversely affected by the students' impatience with having to complete the same survey a second time. While completing the survey they were irritable and unfocused, and their displeasure may have affected their answers. Fortunately, the answers were still positive overall, and no statistical difference existed between the pre and post surveys. The table shows that all of the After Means are lower but statistically these results are not significant.

Although we would have liked to have seen an increase in their motivation qualitatively, the results aren't entirely unsatisfactory. The benefits of the project can be recognized in other ways. The teacher has implemented some of the modules, such as the Gantt chart, into their everyday curriculum. As the middle school students complete the modules and interact with the college students, the team observes all positive feedback. The middle school students are engaged in the activities and work hard to complete them correctly. The middle school students always express interest in the research team coming back to lecture again. They ask thoughtful questions to increase their understanding of the material. The team sees this as a success and hopes that having industrial engineering concepts in their class projects will help the student's realize its' usefulness.

Conclusions and Recommendations

The results of the comparison between the initial and final surveys were not statistically different enough to be significant. The fact that the results did not change suggests that there is some room for improvement in the research team's methods.

In order to improve valance, both the students' value of the behavior and the value of the goal need to be enhanced. To increase the value of the behavior, we can make the exercises and lessons more engaging. Over the course of the study, the students expressed enjoyment of the activities. Although the students are having fun, some of the aspects that make up valance are still lacking that make up the value of the behavior. In the future, we should make the activities more challenging and more competitive to make them engage with the activity and each other. Specifically, we would like to try to bring students more into the lesson, add more visual aids, vary the teaching techniques and give the students more opportunities to be creative. To increase the value of the goal, we would like to give the students a more thorough definition of what an industrial engineer does and why it is important. We would like to show the students the secondary goals and benefits of learning industrial engineering tools. Some secondary benefits are enhanced project management skills, informed decision making capabilities, and becoming a more detailed communicator.

To increase the instrumentality portion of the students' motivation, we need to create a stronger sense that the lessons and activities we do with them are closely related to industrial engineering. It does not seem like they fully grasped what industrial engineering is, making it difficult to see the correlation between our lessons and the actual field. In the coming months, the research team should explain how industry professionals use the IE tools taught in class. We are going to try to relate the importance of every module back to industrial engineering.

Finally, to improve the expectancy, we need to make the students believe that they will be successful if they pursue industrial engineering. To do this, the team should make an effort to increase the pupils' self-efficacy. The students need to perceive they have the knowledge, skills and resources to complete the modules. If the activities were more challenging and the students were still able to achieve success, they might feel more capable. Also, if we gave the students more positive feedback, it might increase their expectancy. Another thing we would like to do is give the students more time for questions and better demonstrate that the lecturing Clemson student are competent on the topics that they are teaching (Switzer 2004).

Overall, the study was an interesting and informative exercise that should help us improve the modules and our visits to the middle school and hopefully increase the students' motivation in the future. Luckily, we still have sufficient time to make improvement on our lessons for the middle school students and we can positively impact their desire to become an industrial engineer.

CHAPTER FOUR

RECOMMENDATIONS FOR FUTURE PROGRAMS

Advice for All Industrial Engineering Education Programs

VIE Theory offers some insight to ways to improve motivation, and additionally or student interviews provide great advice for authentic learning programs. If engineering education programs survey the participants, they could personalize the experience to increase that individual's motivation to become an industrial engineer. The surveys used in this study could be used because they have already been proven reliable.

For students who have a low V*alue of the Behavior* the lessons should be more engaging. Students should be given challenging and competitive activities that allow them to be creative. The students should be brought into the lesson, more visual aids should be used, and teaching techniques should be varied (Switzer 2004). The participants in this study gave us further insight into what factors contributed to their V_b. The people involved in the program have a great impact on the student's enjoyment. Your program should stress relationships between faculty, peers, and teamwork to increase motivation. Your program should highlight the parts of IE that students appreciate the most, like versatility, mobility, application, and working with people. Your program could supply projects and lessons that exemplify these characteristics. By creating lower-level goals, students' V_b will also increase, especially the goals of contribution and recognition. The feeling of accomplishment before reaching the ultimate goal will increase V_g. Your program should promote well rounded lifestyle, a positive outlook on life, and a true interest in the material. Increasing the value of the behavior will increase student's motivation.

For students who have a lower *Value of the Goal* material should help them value the profession more. They should be given a thorough definition of what an IE does and its importance relative to a variety of fields, especially the ones they are most interested in. Secondary goals and benefits of learning IE tools (enhanced project management, informed decision making, improved communication skills, etc.) should be introduced at the beginning of the project (Switzer 2004). Students from the interviews had some additional ways to increase Value of the Goal. For starters, students enjoy telling others about their work. Authentic learning programs should encourage students to tell people outside the career about what they are doing. There are many facets of IE that students value, and if your projects showcased these aspects you could increase how much they valued the goal of Industrial engineering. Participants in this study suggest that the application of and benefits of industrial engineering are very important to demonstrate. Also, Industrial engineering's versatility, should be stressed, especially because 100% of the interview participants discussed this. Students often chose IE because it would allow them to work with people.

To increase the *Instrumentality* the program should create a stronger sense that the project is closely related to what IE's do in the real world. The correlation between the program and the field of Industrial Engineering is essential to motivate students. (Switzer 2004). Information from the interviews tell us that programs should stress individual student recognition. The application of material is useful for student instrumentality. Also, by teaching them useful topics that they can understand how they will use in the future will also increase their I. If students care enough about their project to share it with others, their instrumentality will also be increased.

For students' with a low expectancy, the program should help students believe that they will be successful if they pursue IE. Activities should be challenging so when they are still able to achieve success, they will feel more capable. Positive feedback should be frequently given. The competence of the mentors should be proven so the students feel they have a good model to follow (Switzer 2004). The interviews also had some interesting insights into Expectancy. Students recognize many different resources in our interviews: classroom content, co-workers, people in other fields, professors, time, parental support, teaching assistants, time, parents, and other authentic learning programs. Students identify several characteristics necessary for success as an IE. Your program could help them achieve these characteristics. Students should strive to have effort, drive, persistence, intelligence, problem solving and analysis skills, communication skills, creativity, leadership, and organization skills. Your program should promote these skills throughout their duration.

Advice for the Clemson University Department of Industrial Engineering

Although the program and department are quickly growing, it is very important to remember that every student is unique. Traditionally education has followed a one-size-fit-all type of style, but there are movements to increase the use of personalized learning to make learning more reliable (Grand Challenges for Engineering: Advance Personalized Learning n.d.). The results of this study further prove the need to remember that every student is an individual. Students may meet all the technical requirements to take a class, but the prerequisites does not remove all the variance in the class. Each student enters the classroom or program with a different set of experiences and scaffolding. It is important to figure out how to maximize the individual student's motivation based on their needs in order to produce successful industrial engineers. Faculty members should continue to get to know each student and ensure their learning environment is optimized.

All authentic learning programs should contain a disclaimer to help avoid motivation detractors. The students should be aware that they are participating in a real-world problem solving experience that is a single instance of how industrial engineering could be applied in the real world. The experiences will never be all encompassing of every field, every tool, and every situation that an industrial engineer could be working in the future.

The program should strive to stress and achieve the subthemes mentioned by a majority of the students who participated in the qualitative study that they can have a positive impact on. The department should continue to stress the versatility of the degree because every student in the study mentioned this as a major contributor to their motivation. Students are motivated by the fact they can work in a variety of industries, apply a variety of tools, and work in a variety of locations with their degree. The department should continue to encourage friendships and relationships between students within the department.   The department should give students recognition for contributions and projects well done. They should continue to reward students who excel. The departments should continue to emphasize the importance of classroom content and show students how it is applied in the real world. The program needs to help students deal with others' opinion of the degree. The professors should continue to build relationships with individual students, whether it be through advising, undergraduate research, or in the classroom as well as make themselves available to students as a resource. The department should try to get students truly interested in the material and stress secondary benefits like organization and project management skills. Finally, the department should give examples of how former graduates have made a difference in the world or in someone's lives because many of the participating students listed this as a motivating factor to succeed.

APPENDICES

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 (CI, Co-op, etc) If CI, 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

Sample Lesson Plans

Lesson Plan: Standard Work Instructions

Time:		Duration: 5 min
• Administer Attitude Survey		
Time:		Duration: 2 min
• Verbally explain to the students that they must come up with directions to walk the teacher through making an Ice Cream Sundae as if he was born yesterday. • Show the students the materials that can be used for making the Sundae		
Time:		Duration: 8 min
• Write the students' suggestions for the steps to make an Ice Cream Sundae on the board.		
Time:		Duration: 6 min
• Actually follow the students' directions (very literally) and make an Ice Cream Sundae.		
Time:		Duration: 8 min
• Explain that the set of directions the students just made was called "Standard Work Procedures." • Show Powerpoint while asking the students the following questions to keep them involved in the lecture.		
	Slide #	Question… *We can come up with specific questions to keep the students involved on Thursday
Time:		Duration: 6 min
• Explain the Lego activity • Put the students into groups while handing out the pre-built Lego shapes • Make sure the students know that their performance is evaluated by how well the other group can follow their Standard Work Procedures		
Time:		Duration: 10 min
• Have the students write out their Standard Work Procedures for building the Lego shapes • Help if needed, but don't give them any "answers." Let the students write out the steps in a way that they understand them		
Time:		Duration: 2 min
• Have the groups take apart their Lego shape • Explain to the students that they will now switch Lego shapes and Standard Work Procedures. • Pass the Lego shape pieces and the Standard Work Procedures that go with it to the next groups so every group has another groups'.		
Time:		Duration: 8 min
• Have each group try to assemble the Lego shape with the Standard Work		

Procedures from another group.	
Time:	Duration: 5 min
• Ask the students to name some benefits of having Standard Work Procedures • Ask the students to name ways they can improve their Standard Work Procedures after having seen the way other groups wrote theirs. • Ask the students to name any situation or job that may use Standard Work Procedures	

Lesson Plan: Probability

Time:	Duration: 5 min
• Ask the students what they know about probability • Have them give examples of when probability is used and write them on the board	
Time:	Duration: 10 min
• Go over probability slides • Have the students fill out their worksheets as we go over them • Give examples of when Engineers use probabilities	
Time:	Duration: 3 min
• Pass out handouts and M&Ms for activity • Make sure to tell the students to NOT EAT the M&Ms yet!	
Time:	Duration: 5 min
• Have the students separate the M&Ms by color • Have them record their data on the worksheet	
Time:	Duration: 25 min

• Tell the students they can eat the candy
• Collect the data from all the students and have 'Master Sample Table'
    o Have each row tally up how many of each color they had and then record how many overall the class had of each color
    o The table will show how many reds, blues…etc for the whole class
• Have a student explain how to calculate the probability of getting a certain color M&M
• Have the students fill out the remaining probabilities individually on their worksheet	

Time:	Duration: 10 min
• Ask the students questions about the activity and what they think about probability • Have the students Clean up	

Appendix E

Sample Worksheets

Presentation Worksheet: Standard Work Instructions

What are Standard Work Instructions?

- Standard Work Instructions (SWI's) are *specific instructions that allow processes to be completed in a consistent, timely, and* ___________________ *manner.*

Why use SWI's?

- Increase production
- Improve ____________
- Make for a safer, predictable working environment

How to Generate SWI's

- Think of *ALL* the steps needed to complete the given process.
- Place steps in correct ____________.
- Include as many details as necessary to complete process correctly and efficiently.

Examples of SWI's

- ______________________________
- ______________________________

Appendix F

Sample Activities

Decision Analysis Activity

You are the President of Clemson University! You are trying to decide how to spend your money. The athletic department would really like a new stadium, and students would like a new dining hall to be constructed. The success or failure of both options depends on how well the football team performs. If the Tigers have a winning season, the stadium will make $100k, but if they have a losing season, the university will *lose* $40k on the investment. If the Tigers have a winning season, the dining hall will make $30k, because more students will be attracted to Clemson because of the awesome football team. However, if they have a losing season, the dining hall will only make $10k.
Which do you choose to build (the dining hall or dormitory)?

Flip a coin 10 times and record your outcomes. Heads = Win and Tails = Loss.

Heads (Wins)	Tails (Losses)

Now, calculate the probabilities of having a winning or losing season.

Winning Season	Losing Season

Fill in the table below and find the expected values using your probabilities found above.

	Outcomes		
Choices	Winning Season	Losing Season	Expected Value
Stadium			
Dining Hall			
Probability			

Did you make the best decision?

What information could have helped you make a better decision?

Appendix G

Middle School Student Motivation Survey

School Assigned Password: ______________
Gender: ___ Male _____Female
Race: _____ African American ______Hispanic ______Caucasian _____ Asian
Grade: _____6th _____7th ______8th
I have considered being an Industrial Engineer: ______Yes ______No

Directions: Please select how strongly you agree or disagree with each of the following statements by circling the best representative of your opinion.

1= Strongly Disagree 2=Disagree 3= Neutral 4= Agree 5= Strongly Agree
Note: IE means Industrial engineering

1. I may want to be an engineering major in college.	1	2	3	4	5
2. Industrial Engineers play an important role in our society.	1	2	3	4	5
3. I am good at problem solving.	1	2	3	4	5
4. I am capable of developing the skills necessary to be an Industrial Engineer.	1	2	3	4	5
5. Industrial engineering improves the quality of life for our society.	1	2	3	4	5
6. I can solve problems using IE tools.	1	2	3	4	5
7. I am confident that I know what Industrial Engineers do.	1	2	3	4	5
8. I would enjoy being an Industrial Engineer.	1	2	3	4	5
9. I like when the Clemson students come to our school.	1	2	3	4	5
10. The course work for IE in college will be manageable.	1	2	3	4	5
11. I think it is possible for me to become an engineer.	1	2	3	4	5
12. I get satisfaction from doing well in the IE lessons the Clemson students give.	1	2	3	4	5
13. Taking this class will help prepare me to be an engineer.	1	2	3	4	5
14. I am being exposed to new ideas in my engineering class.	1	2	3	4	5
15. I am a big-picture thinker.	1	2	3	4	5
16. I get satisfaction from my coursework.	1	2	3	4	5
17. My projects are preparing me to be an engineering major.	1	2	3	4	5
18. I use my industrial engineering knowledge outside of school.	1	2	3	4	5
19. I can apply knowledge from the IE lessons to other projects.	1	2	3	4	5
20. Engineering improves the quality of life for our society.	1	2	3	4	5
21. Taking this class will prepare me to do well in college.	1	2	3	4	5

Appendix H

Middle School Student Motivation Survey Item/Construct Correlation

Mapping of Items to Constructs

Value of the Behavior: *How much do the students value the Industrial engineering lessons added to their curriculum?*

6. I can solve problems using IE tools.
9. I like it when the Clemson students come.
12. I get satisfied from doing well in my IE lecture that the Clemson students give.
14. I am being exposed to new ideas in my engineering class.
16. I get satisfaction from my coursework.

Value of the Goal: *How much do the students value the Industrial engineering profession?*

2. Industrial Engineers play an important role in our society.
5. Industrial engineering improves the quality of life for our society.
8. I would enjoy being an Industrial Engineer.
18. I use my industrial engineering knowledge outside of school.
19. I can apply knowledge from the IE lessons to other projects.
20. Engineering improves the quality of life in our society.

Instrumentality: *If a student is successful in the engineering class will he be successful as an industrial engineer?*

10. The course work for IE in college will be manageable.
11. I think it is possible for me to become an engineer.
13. Taking this class will help prepare me to be an engineering major.
17. My projects are preparing me to be an engineering major.
21. Taking this class will prepare me to do well in college.

Expectancy: *Do the students have enough knowledge about industrial engineering to pursue it further?*

1. I may want to be an engineering major in college.
3. I am good at problems solving.
4. I am capable of developing the skills necessary to be an Industrial Engineer.
7. I am confident that I know what Industrial Engineers do.
15. I am a big-picture thinker.

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