5-2009

WARNING! Engineers in Training: Introducing Middle School Students to Industrial Engineering, its Usefulness, and its Applications

M. Grubb

A. Berger

D. Browning

M. Mayorga

Laine Mears
Clemson University, mears@clemson.edu

WARNING! Engineers in Training: Introducing Middle School Students to Industrial Engineering, its Usefulness, and its Applications

Abstract

The McCants Middle School Pre-engineering class is designed to teach engineering skills to students with a predisposition for and interest in math and science. This team's initiative is to use Industrial Engineering tools to enhance the existing pre-engineering course curriculum. The purpose of this study is to make middle school students better aware of an engineer's thought process as it pertains to effectively planning and working on projects, and to measure the impact of our influence. Through this study, we want to improve the overall quality of the student's projects and ultimately increase the retention and quantity of students interested in the engineering field. The current curriculum is limited to very few engineering disciplines, and the team will broaden the students' knowledge of more types of engineering and how the various disciplines interact in industry. Undergraduate Industrial Engineering students ranging from sophomores to seniors presented lessons to middle school students in pre-engineering on the topics of production planning, cost analyses, quality control, and logistics. In every lesson, a hands-on activity accompanied the presentation, and students were asked to complete the activity in small groups to solidify the concepts and promote networked learning.

Through observation and attitude surveys, the team discovered that interactive discussions and hands-on activities were far more conducive to understanding and concept retention than lectures. As the study progressed, more of the students participating in the class became further interested in the pre-engineering class. The students' projects were of better quality, and the inclusion of solution brainstorming and project planning made the exercise of completing the project more valuable to the students. Quantitatively, the team was unable to prove that their influence had a statistically significant impact. However, the team's observations show that the changes to the middle school pre-engineering class made the students more excited about and more aware of real-world engineering.

1. Introduction

The research team was made up of five Undergraduate Industrial Engineering students from Clemson University. The participants in the study were about 120 students, ranging from 6th to 8th grade. The current curriculum of the pre-engineering program was based mostly on mechanical engineering concepts. Pre-engineering programs are a relatively new concept that is being introduced into middle and elementary schools nationwide. The students in the pre-engineering class were recommended for the program by their teachers based on high performance in math and science classes. The purpose was to explore the effectiveness of modules created by the team on middle school students' knowledge and attitude of industrial engineering disciplines. Additional benefits consisted of broadening the student's knowledge of engineering, specifically Industrial Engineering, teaching them and their teacher to better manage their projects, and expanding the scope of the material covered 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 one's attitude or feelings regarding a particular subject, quantitative research was performed. 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, VIE Motivation Theory was referenced.

2. Theoretical Perspectives

A very useful tool in motivational theory is VIE theory [1]. It states that motivation is based upon three independent variables, Valence, Instrumentality, and Expectancy and follows the equation

$$M_{b \rightarrow g} = V * I * E \tag{1}$$

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 increases, the motivation to perform the behavior increases. The multiplication signs indicate that all 3 components must be present for motivation to exist. Valence is comprised of 2 additive components,

$$V = V_g + V_{b,} \tag{2}$$

where V_g denotes Value of the Goal and V_b denotes Value of the Behavior. Value can come from participating in the activity or the goal the behavior 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 Vg or Vb must have a positive valance for motivation to exist. If the Valence term is negative, then avoidance of the activity exists rather than motivation. Instrumentality (I) is the perception of the behavior′s utility, or usefulness to achieving goals. An individual will judge the probability that completion of the behavior will help them achieve their goals. Expectancy (E) 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.

3. 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 A. 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 as often as possible. 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 the team taught them 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 4 modules over the course of the semester, covering the topics of Gantt Charts, Standard Work Instructions, Probability, and Decision Analysis.

4. 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 what was being presented, not 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 B. Formative assessments were based on our observations of the lectures and suggestions from the teacher. These were 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 C. 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 1: The students participating in the IE activities

5. 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 an Attitude Survey. The survey was approved by the teacher, the principal, and the IRB in protocol IRB2008-340. The survey used can be found in Appendix D. The mapping of the survey questions to the VIE constructs can be found in Appendix E. 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 1. 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 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.

6. 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.

$$\text{Coefficient } \alpha = N/(N-1)*(\text{Variance of Sums} - \text{Sum Item Variance})/(\text{Variance of Sums}),$$

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 [2]. 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 2. 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 2: Results from Attitude Surveys

Construct	Pre Survey Mean	Post Survey Mean	Pre Survey Standard Deviation	Post Survey Standard Deviation	α Coefficient	Statistical Significance (p-value)
Value of the Behavior	0.98	0.91	0.45	0.61	0.68	0.72
Value of the Goal	0.96	0.92	0.60	0.66	0.67	0.53
Instrumentality	1.10	0.99	0.53	0.58	0.75	0.13
Expectancy	0.85	0.71	0.55	0.63	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.

7. 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 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.

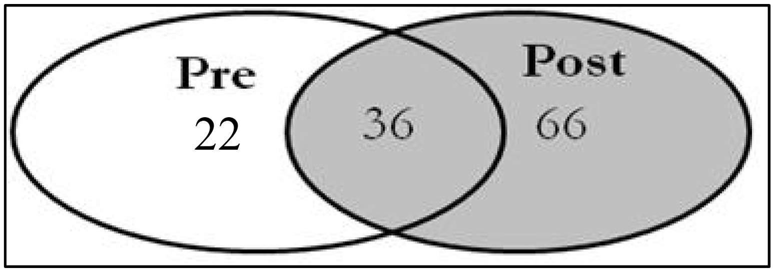

Figure 2: Students that Participated in Attitude Surveys

We suspected that the results of the final survey might be skewed as it was being administered, as the students expressed impatience at having to do 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 easily recognized through other manners. 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 students 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.

8. 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. We would like to specifically 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 doesn't seem like they really 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 the IE tools taught in class are used in industry by professionals. 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 [3].

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.

9. Acknowledgements

There are many people we would like to thank for making this a valuable research experience. Without our faculty advisor and graduate student mentor, Dr. Maria Mayorga and Danielle Lanigan, this study would not have been possible. Two other members of our group, sophomores Kelly Springfield and Darla Browning, assisted in our research. We would like to thank McCants Middle School and Mr. Billy Little for allowing us to work with their students. We would also like to thank Dr. Trenor and Dr. Benson for advising us on our research methods.

References

1. Green, T. B. (1992). *Performance and Motivation for Today's Workforce: A Guide to Expectancy Theory Applications.* London: Quorum Books.

2. Benson, Lisa and Switzer, Deborah (2007) *Assessing Impact of Outreach Activity on Motivation of Undergraduate Engineering Students.* American Society for Engineering Education

3. Switzer, Deborah M(2004). “Individualized Instruction” pg. 225-233 *Helping Students Graduate: A Strategic Approach to Dropout Prevention.* Jay Smink and Franklin Schargel (editors) Richard H Adin Freelance editorial services.

Appendix A
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		
Time:		Duration: 5 min
• Clean up, etc.		

Lesson Plan: Probability

<table>
<tr><td>Time:</td><td>Duration: 5 min</td></tr>
<tr><td colspan="2">• Ask the students what they know about probability
• Have them give examples of when probability is used and write them on the board</td></tr>
<tr><td>Time:</td><td>Duration: 10 min</td></tr>
<tr><td colspan="2">• Go over probability slides
• Have the students fill out their worksheets as we go over them
• Give examples of when Engineers use probabilities</td></tr>
<tr><td>Time:</td><td>Duration: 3 min</td></tr>
<tr><td colspan="2">• Pass out handouts and M&Ms for activity
• Make sure to tell the students to NOT EAT the M&Ms yet!</td></tr>
<tr><td>Time:</td><td>Duration: 5 min</td></tr>
<tr><td colspan="2">• Have the students separate the M&Ms by color
• Have them record their data on the worksheet</td></tr>
<tr><td>Time:</td><td>Duration: 25 min</td></tr>
<tr><td colspan="2">• 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</td></tr>
<tr><td>Time:</td><td>Duration: 10 min</td></tr>
<tr><td colspan="2">• Ask the students questions about the activity and what they think about probability
• Have the students Clean up</td></tr>
</table>

Appendix B
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 C
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 D
Attitude 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 E
Survey Question Construct Mapping

<u>Mapping of Items to Constructs</u>

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.