A Mixed Method Study on the Impact of Industry Sponsored Projects on Senior Capstone Design Student’s Motivational Factors

by

Devanshi Shah

A thesis submitted to the Graduate School of Florida Institute of Technology in partial fulfillment of the requirements for the degree of

Masters in Mechanical Engineering

Melbourne, Florida
May, 2019

Dr. Beshoy Morkos  
Associate Professor  
College of Engineering and Science

Dr. Kastro Hamed  
Professor  
College of Engineering and Science

Dr. Chiradeep Sen  
Assistant Professor  
College of Engineering and Science

Dr. Ashok Pandit  
Department Head  
College of Engineering and Science
Abstract

Title: “A Mixed Method Study on the Impact of Industry Sponsored Projects on Senior Capstone Design Student’s Motivational Factors”

Author: Devanshi Dhirenkumar Shah

Advisor: Dr. Beshoy Morkos, Ph.D.

This thesis examines the change in student motivation through a yearlong senior capstone design course with respect to their choice of project type. The senior capstone design projects offered at the university fall into one of two major project types: industry sponsored and non-industry sponsored. The students opt for either of the two major project types based on their interest and future career goals. The students were given an adapted version of Motivated Strategies for Learning Questionnaire (MSLQ) to self-identify their motivation levels by rating various questions on a 7-point Likert scale. The surveys were conducted at two different points in time throughout the yearlong senior capstone design course: at beginning of the fall semester, two weeks into the school year when the students were not fully introduced to their project topics; and again at the end of the spring semester after their projects were completed and the senior capstone design course was concluding. Five motivation factors were studied to examine student motivation within and between the cohorts: cognitive value, self-regulation, presentation anxiety, intrinsic value, and self-efficacy. The data was collected from three cohorts of mechanical engineering senior capstone design students, through three different yearlong senior capstone courses: 2013-2014, 2014-2015, and 2016-2017. The data was analyzed using an ANOVA Single Factor analysis and a paired t-test for single variance to examine which factors affected student motivation.
This thesis further outlines the development of a coding scheme to support the study examining the impact of project type on student motivation and change in motivation through senior capstone design. Exit interviews were conducted with each of the senior capstone design project teams at the end of the spring semester after the conclusion of the senior design course. In a thirty minute interview session, teams were asked a set of nineteen questions regarding their experience throughout the senior design course. The collected interview data from each of the teams was transcribed for analysis. A coding scheme is developed to analyze the qualitative interview data to indicate which of the motivation factors influenced their performance in the course. The data is also analyzed to determine how the student motivation changes over the course of the senior capstone design course based on the student’s project choice (industry-sponsored versus non-industry sponsored).

The goal of this research is to examine the effect of the student’s choice of project type on their motivation and changes in motivation in senior capstone design. This will thereby provide educators with insight on the impact of the student’s project selection on their senior capstone design experience. Thus, the aim is to provide a broader perspective on the senior capstone design curriculum by catering the project offerings that positively impact the student’s experience, increasing their motivation and improving their performance in the course.
# Table of Contents

<table>
<thead>
<tr>
<th>Table of Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Figures</td>
<td>vii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>viii</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>ix</td>
</tr>
<tr>
<td>Dedication</td>
<td>x</td>
</tr>
<tr>
<td>Chapter 1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Motivation of Research</td>
<td>3</td>
</tr>
<tr>
<td>Research Addressed</td>
<td>4</td>
</tr>
<tr>
<td>Chapter 2 Background</td>
<td>7</td>
</tr>
<tr>
<td>Senior Design</td>
<td>7</td>
</tr>
<tr>
<td>Senior Design at Florida Tech</td>
<td>8</td>
</tr>
<tr>
<td>Project Based Learning in Senior Design</td>
<td>9</td>
</tr>
<tr>
<td>Industry Projects</td>
<td>9</td>
</tr>
<tr>
<td>Non-Industry Projects</td>
<td>12</td>
</tr>
<tr>
<td>Project Type Difference - Requirements</td>
<td>14</td>
</tr>
<tr>
<td>Motivation</td>
<td>15</td>
</tr>
<tr>
<td>Factor 1: Cognition</td>
<td>17</td>
</tr>
<tr>
<td>Factor 2: Intrinsic Value</td>
<td>18</td>
</tr>
<tr>
<td>Factor 3: Self-regulation</td>
<td>18</td>
</tr>
<tr>
<td>Factor 4: Test/Presentation anxiety</td>
<td>19</td>
</tr>
<tr>
<td>Factor 5: Self-efficacy</td>
<td>19</td>
</tr>
<tr>
<td>Qualitative Data Collection and Analysis</td>
<td>20</td>
</tr>
<tr>
<td>Exit Interviews</td>
<td>21</td>
</tr>
<tr>
<td>Coding Scheme Data</td>
<td>22</td>
</tr>
<tr>
<td>Reliability Tests</td>
<td>23</td>
</tr>
<tr>
<td>Summary of Research Gaps and Findings</td>
<td>24</td>
</tr>
<tr>
<td>Chapter 3 Research Methods</td>
<td>26</td>
</tr>
<tr>
<td>Quantitative Instrument</td>
<td>26</td>
</tr>
<tr>
<td>Qualitative Instrument</td>
<td>27</td>
</tr>
<tr>
<td>Study Subjects</td>
<td>28</td>
</tr>
<tr>
<td>Data Collection: Survey</td>
<td>28</td>
</tr>
<tr>
<td>Data Collection: Interview</td>
<td>29</td>
</tr>
<tr>
<td>Quantitative Data Analysis</td>
<td>31</td>
</tr>
<tr>
<td>Qualitative Data Analysis</td>
<td>32</td>
</tr>
<tr>
<td>Mixed Methods Data Analysis</td>
<td>33</td>
</tr>
<tr>
<td>Chapter 4 Results</td>
<td>35</td>
</tr>
</tbody>
</table>
# Table of Contents

ANOVA Single Factor Analysis ................................................................................................................. 35
Mean Comparison Results.......................................................................................................................... 39
Senior Capstone Design Coding Scheme ............................................................................................... 40
  Theme 1: Project Selection ...................................................................................................................... 40
  Theme 2: Project Process ....................................................................................................................... 43
  Theme 3: Results .................................................................................................................................... 46
 interrater Reliability of Coding Scheme .................................................................................................. 48

Chapter 5 Discussion .................................................................................................................................. 50
  ANOVA Single Factor Analysis for Senior Project Groups ................................................................. 50
  Mean Comparison of Projects ............................................................................................................... 52
  Project Selection ..................................................................................................................................... 52
  Project Process ....................................................................................................................................... 53
  Project Results ....................................................................................................................................... 55
  Inter-rater Reliability: ............................................................................................................................ 56
  Addressing Proposed Research Questions ............................................................................................ 57

Chapter 6 Conclusion and Future Work .................................................................................................... 58

References ..................................................................................................................................................... 60

Appendix A: MSLQ Survey ......................................................................................................................... 70
Appendix B: Exit Interview Questions ....................................................................................................... 74
Appendix C: IRB Documentation ............................................................................................................... 77
Appendix D: Coding Scheme ..................................................................................................................... 83
Appendix E: Original Coding Scheme Draft ............................................................................................ 84
List of Figures

Figure 1: Coding Items for Selection Theme .......................................................... 41
Figure 2: Coding Items for Process Theme ............................................................ 44
Figure 3: Coding Items for Results Theme ............................................................. 47
List of Tables

Table 1: Summary of Research Questions and Hypothesis .................................................. 5
Table 2: Summary of the Objectives and Tasks necessary to address each Research Question (RQ) .................................................................................................................. 6
Table 3: Cohen's Kappa Interpretation .................................................................................... 24
Table 4: Motivation factors in MSLQ survey .......................................................................... 27
Table 5: Subjects Gender and Project Selection Information ............................................. 28
Table 6: Exit Interview Questions ......................................................................................... 30
Table 7: Participants in the Qualitative Exit Interview ......................................................... 31
Table 8: Fall and Delta Cognitive Values ............................................................................ 36
Table 9: Spring and Delta Intrinsic Motivation Values ......................................................... 37
Table 10: Spring and Delta Self Efficacy Values ................................................................ 37
Table 11: Self-Regulation Values during Fall Semester ....................................................... 38
Table 12: Presentation Anxiety Fall Semester ...................................................................... 38
Table 13: Statistically Significant Results of ANOVA Analysis ......................................... 39
Table 14: Means and Standard Deviations of Statistically Significant Factors ................. 40
Table 15: Code Frequency Table ........................................................................................ 49
Table 16: Summary of Research Questions Findings ......................................................... 57
Acknowledgement

Firstly, I would like thank my research advisor Dr. Beshoy Morkos for introducing me to the world of research and this amazing research field of engineering education. Not only did I research on motivation but my personal motivation reached its highest level while working with him. Blessed to have you as my advisor.

Secondly to my committee members for their assistance on my research and thesis. Also a great thank you to my research team members, Lisa Kames and McKenzie Clark for all the support and my lab mates in STRIDE Lab for being such a wonderful family at Florida Tech.

Last but not the least, my parents, Nutan Shah and Dhiren Shah and sister, Rashi Shah for believing in me and seeing the potential in me which I struggled to see. Thank you.
Dedication

“Once upon a time, you were a little girl with big dreams that you promised you’d make real one day, *don’t disappoint yourself.*”
Chapter 1
Introduction

In this study, we aim to explore the effects of student’s selection of senior design project on their motivation level. Mechanical engineering students in their Capstone Senior Design course are offered various project types to choose from. Students have an option to select their projects from three major categories: Industry sponsored, Competition and Humanitarian projects. These categories further offer various options on sub topics based on the interest of the student. Most of the universities in United States offer industry sponsored projects in their senior capstone design course to give students an opportunity to work with real world industry projects.\(^1\) However, little is known about the impact such projects have on students, and if the utilization of industry sponsored projects promote student learning or increase motivation towards their discipline. To that end, we explore differences in student motivation between those who select industry versus non-industry projects. For this research we combined the competition projects and humanitarian projects under the category of non-industry projects. This assists the research in dividing the students into two major categories of industry sponsored projects and non-industry projects.

Capstone design has become a centerpiece of student experiential learning within the engineering curriculum. Further, it has afforded engineering educators an opportunity to engage in seeing how students learn in nontraditional modes (compared to the in the classroom counterpart). Capstone design courses were introduced to most of the universities in United States after engineering education faced criticism about the student’s readiness to enter the industry to face the real world problems.\(^2\) In an effort to understand the impact of senior design, we aim to understand how a particular project type impacts students. By understanding what project type contributes to student’s motivation in senior design, we aim to improve the educational process of the course by offering students with
better project options. This is done by specifically targeting those project topics which are found to have an impact on the student’s motivation during the entire course period.

According to Thomas Kuhn, engineering education has the same attributes of an emerging field which undergoes evolution. We aim to make this study one such attribute by contributing to the larger goal of improving the education system for the future engineers in making. Our previous quantitative research on examining motivation in senior capstone design students lead us to the qualitative analysis for the same goal. In this study we aim to develop a coding scheme from the exit interviews conducted by the researchers with the senior capstone design teams.

It is observed that solving engineering design problems by qualitative and quantitative method is beneficial which lead to the motivation to conduct a qualitative analysis in determining the factors which play a significant role in student motivation in senior capstone design course.

A 30 minute structured interview was held between each team and the researchers in this study. The identities of the students participating are kept anonymous. The interviews were conducted at the end of the spring semester after the completion of the design course. The teams had volunteered to participate and share their experiences with the research team. The data was collected in audio format and transcribed later for analysis. Researchers, myself and another research assistant, independently generated themes, categories and codes solely from the data transcribed.

This research was conducted at Florida Institute of Technology consisting of 9 senior capstone design teams. The teams either belonged to industry sponsored projects or non-industry sponsored projects. Industry sponsored projects are offered by private, government and private-government combined companies. Non-industry projects on the other hand included humanitarian projects and competition projects which are university sponsored projects. Tinto identified two important factors determining a student’s
persistence: student commitment and institutional commitment, he also believed that student commitment played a significant role in the retention rate.\textsuperscript{6,7}

There has not been enough research on how project choice play any role in student motivation. Thus the goal of this study is to answer the ultimate research question, “Does student’s selection of industry project vs non-industry project in senior capstone design course have any significant effect on their motivation levels?” Thus this study serves as the connecting bridge to that ultimate goal. This study aims to support the previously conducted quantitative research which examined the factors affecting student motivation throughout the year based on their project choice.

**Motivation of Research**

The importance of Senior Capstone Design in engineering curriculum cannot be understated. Often, it is cited as the most important course students complete throughout their education. However, there is a great disparity in how senior design is run at various universities. One such variation is the type of project student’s experience. Specifically, if the project is industry sponsored or not. Industry and non-industry sponsored projects offer a different experience to students. Industry sponsored projects provide students with more real industry/manufacturing problems by closely working with the industry clients. Non-industry projects on the other hand provide students an opportunity to work in larger team and have their own research areas to work on. However, it is unknown if the benefit of the project type is equal. Moreover, little is known about the impact the project has on their motivation. Motivation is considered here as many students have a change or reinforcement of motivation based on their first formal engineering design experience – as it is the closest experience to being an engineer. Thus, this research aims to address the gap in understanding how student motivation is affected by the type of project students participate in. The goal of this research is to shed light on how senior design capstone projects should be assigned and administered to students to ensure their motivation toward engineering is maintained (or increases) throughout their capstone experience.
Research Addressed

This study is performed through a one-year longitudinal analysis whereby a cohort of senior design students are observed throughout their project duration (fall and spring semester of senior year). Three cohorts are considered whereby each cohort is studies longitudinally. The cohorts behold to three different senior design years: 2013-2014, 2014-2015 and 2016-2017. Data is collected utilizing the Motivated Strategies for Learning Questionnaire (MSLQ) twice during their senior capstone design course. First in the beginning of the fall semester when they are introduced to their project (two weeks into the course). The second part of the data is collected in the end of the senior design course that is in the spring semester, approximately two week before the school curriculum ends for that academic year. This data is compared against the type of project students selected: industry sponsored versus non-industry. The objective of this research is to address the four research questions posed in Table 1. To address the research questions, an objective is defined whereby tasks care carried out to address the questions. The objectives and tasks, shown in Table 2, are executed in this research and the findings are detailed in this thesis.
### Table 1: Summary of Research Questions and Hypothesis

<table>
<thead>
<tr>
<th>ID</th>
<th>Research Question</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>Are there varying levels of student motivation between those who select industry sponsored versus non-industry projects?</td>
<td>The researchers hypothesize that there are varying levels of motivation observed between students who select one type of project compared to their counterpart</td>
</tr>
<tr>
<td>RQ2</td>
<td>Does the project type have a significance on the change of student motivation throughout the project duration?</td>
<td>The researchers hypothesize no differences are observed in changes to student motivation between industry sponsored and non-industry projects</td>
</tr>
<tr>
<td>RQ3</td>
<td>Could a coding manual and scheme with significant themes be developed specifically for Senior Capstone Design course application?</td>
<td>The researchers hypothesize that a coding scheme can be developed that is both reliable and addresses multi-facets of senior design</td>
</tr>
<tr>
<td>RQ4</td>
<td>Can qualitative data analysis using the aforementioned coding scheme provide insight on observations realized in the quantitative analysis?</td>
<td>The coding scheme can be used to provide insight and further detail on why student motivation varied between projects and why it changed throughout the course</td>
</tr>
</tbody>
</table>
Table 2: Summary of the Objectives and Tasks necessary to address each Research Question (RQ)

<table>
<thead>
<tr>
<th>ID</th>
<th>Objective</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>The objective of RQ1 is to determine if there is a difference in motivation either at the start or end of the senior design capstone experience based on the project type</td>
<td>Motivation levels are measured between common students on varying types of projects and compared between the beginning and end of the senior design capstone experience.</td>
</tr>
<tr>
<td>RQ2</td>
<td>The objective of RQ2 is to determine if there is a difference in changes to motivation between the start and end of the senior design capstone experience based on the type of project.</td>
<td>The changes in motivation across the senior design capstone experience is measured.</td>
</tr>
<tr>
<td>RQ3</td>
<td>The objective of RQ3 is to determine if a coding manual and scheme can be developed to identify themes and subthemes for how students respond to questions during senior design capstone exit interview.</td>
<td>A coding schemed is proposed, developed, iterated, and measured for reliability to determine if interview questions could be codified.</td>
</tr>
<tr>
<td>RQ4</td>
<td>The objective of RQ4 is to determine if the coding scheme results may be used to support, offer clarity, or reinforce the results of the quantitative analysis.</td>
<td>Determine if coding scheme aligns with the results of the quantitative data.</td>
</tr>
</tbody>
</table>
Chapter 2
Background

As we consider the differences in student projects through the lens of motivation, a motivation background is provided to gain insight on the motivation instrument used and its impact on student learning. Comparison of industry sponsored and non-industry projects are also provided to explain their differences and what students may experience in each of them.

Qualitative research has proved to be beneficial in providing insights which are sometimes missed in the quantitative survey tools. In this research, senior capstone design is specifically targeting as it is known to have a significant impact on students beyond that of the traditional engineering courses. To that end, data is collected from students during senior capstone design to determine how their motivation factors change throughout the course. To provide explanation for quantitative data, qualitative data is necessary as it often sheds light on why students responded a particular way to a question. Alongside any robust qualitative data set is a coding scheme developed specifically to understand the themes and codes of student responses. In the background section, a description of motivation is provided as it is the lens through which students are observed throughout the senior capstone design experience. Additionally, a comparison of the type of projects assigned in the Senior Capstone Design course at Florida Tech is provided.

Senior Design

Senior Capstone Design course is one such bridge that connects students to professional engineering industry. Senior Capstone Design Course is a sole design course offered in the senior year of mechanical engineering where students have an opportunity to design a project (prototype) or work on an existing project to improve its performance by re-designing it. Design is an integral part of mechanical engineering. Students often report to have entered mechanical engineering solely for their curiosity and passion to design
something new. Senior capstone design is also a special course because students get to work as a team (small or large) thus giving them a preview of the industry environment where employees work as team on important projects. Competition projects prove to be a good choice when it comes to re-designing an existing model and improving its performance from the past. Humanitarian projects intend to help people in the lesser developed countries by providing solution to the struggles they face for basic facilities like shelter, food and water. They aim at solving problems by providing cost efficient products so that it is affordable to people all around the world. Humanitarian projects also provide the liberty to students to come up with a problem statement. It doesn’t necessarily have to be from the university or the course instructor. The emergence of this course comes from various sources like the Accreditation Board for Engineering Education ABET, local industries and individual school requirement.\textsuperscript{8} Engineering is a field of consistent hard work, smartness and motivation thus making it one of the most desirable fields in STEM education and equally critical.\textsuperscript{9}

**Senior Design at Florida Tech**

At Florida Tech, Senior Design Capstone spans across three semesters: Second Semester Junior, First Semester Senior, and Second Semester Senior. Design Methodologies introduces students to formal design methodology in an attempt to prepare students for their senior design project. The objective of this course is to equip students with the design knowledge and know-how necessary to successfully complete their design project. The course objectives of Design Methodologies are:

- Utilize various design tools, techniques, and methods employed in engineering design;
- Successfully manage and document projects;
- Recognize the role of analysis, synthesis, and evaluation in design; and
- Apply the fundamental concepts of professional and ethical responsibility
Students in the Design Methodologies course are required to provide the instructor with their top three choices of projects they wish to work on or team mates they want to pair with on the senior capstone design course. They are provided with the list of industry, competition and humanitarian project topics to choose. Students typically select projects based on personal interest and career goals. In all cases, students are assigned to a project (or team mates) that was listed in one of their three choices. Most of the students end up with their desired choice of project or teammates.

During the two senior design courses, students work on and complete their project within their project team. The course allows the student to demonstrate their understanding of the theory in a practical real world engineering challenge and gain experience. Teams present weekly to an advisory board consisting of at least a customer, professor, and a graduate student. This advisory board serves to monitor student progress throughout the course of the project. During the first semester, students define their problem statement, develop requirements, generate concepts, and present a preliminary design review. During the second semester, teams fabricate their design, perform testing, and iterate as needed before submitting their critical design review.

At Florida Tech, particular emphasis has been placed on student motivation and measuring it to ensure students maintain motivation toward engineering. Given that Senior Design is a pinnacle experience for students, it is important to observe changes in motivation as they complete this experience as it could impact their performance in the course. In the past Florida Tech has made efforts to improve student motivation through the development of intervention plans that address the negative motivational factors experienced by students, such as presentation anxiety.

Project Based Learning in Senior Design

Industry Projects

Industry sponsored projects offered are given by local companies by presenting a problem they are currently addressing or wish to do so. The problem statement is described to the
team when entering senior design. Typically, the industry sponsor will host a project kick-off where they provide students with the project, a list of requirements, and their internal deadlines. The goal of industry sponsored senior design team is to provide the company with a feasible solution that meets all their requirements under time and budget constraints. As part of the week to week assignments of the team, an industry representatives holds a weekly or biweekly presentation and feedback interaction with the teams and the faculty. Constructive feedback is given and progress is tracked by the faculty and the clients. The aim of industry sponsored projects is to give students an opportunity to closely work with industry clients and on a problem faced in such an environment thereby gaining valuable experience before they enter workforce. Industry sponsored projects offered at the university are of two types, government funded and privately funded. Industry sponsors include, but are not limited to: NASA JPL, US Navy, Lockheed Martin, Harris Corporations, Google, Northrop Grumman, United Launch Alliance. An example industry sponsored project problem statement is shown below:
The goal of this project is to develop an automated measurement flight hardware connector Break Out Box (BOB) flight applications but require additional features and modifications beyond that of a traditional Smart BOB 1.0. A BOB coupled with your innovative electrical measurement and value verification electronics, cables and software will constitute a “SMART BOB Measurement System”. A BOB used to take powered off and powered on safe to mate electrical measurements from the UUT (Unit Under Test) in electrical integration procedures. A BOB is a large box with 2 connectors (Blk J1, Blk J2). The black and red circular inputs are terminal posts each accounting for one pin on the UUT connector. A BOB is connected in between the UUT and the BOB or in between the UUT and another electronic assemble. The electrical test engineer selectively measures voltage, current or resistance on each and every pin of the UUT with a multi-meter, scope, or current probe per directions documented in an electrical integration procedure. Currently these measurements are taken and documented manually. The goal of this project is to automate the measurement taking, documenting and measurement verification process. You are tasked with developing an automated SMART BOB system by completion of Senior Design.

The first-hand experience of an industry sponsored project helps creating a foundation for future industry needs. A senior capstone design course developed at Brigham Young University, focused solely on the industrial design and manufacturing found that student were excited to see their ideas transform into reality. Similar to industry projects, industry sponsored projects tend to be multidisciplinary in terms of team make up and project requirements.
Non-Industry Projects

Non Industry projects is sub divided into two categories: Competition and humanitarian teams. Competition teams include but are not limited to Formula SAE, Baja SAE, and Drag Car. These teams work towards building a car or redesigning an existing model to compete at a national level competition at the end of the academic year. Competition teams are generally larger in size compared to that of their Industry sponsored counterpart. The larger teams are typically comprised of smaller sub teams that focus on subject areas such as powertrain, chassis, and suspension. Competition teams face a different challenge as leadership is critical to ensure the team is functioning properly. Moreover, the systems engineering aspect of the design plays a critical role to ensure all sub teams are properly communicating and interfacing. These types of projects usually offer students a different type of learning, Industry teams face rigorous industry working environment and competition/research environment for the non-industry projects (hence why we hypothesize there are differences in student motivation between project types). An example Competition Project problem statement is shown below:
Project: Formula SAE

Your objective is to develop a Formula style race car for a fictional manufacturing company to be evaluated at the annual Formula SAE Competition. The functioning vehicle will be evaluated based on the following criteria:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Design</td>
<td>150</td>
</tr>
<tr>
<td>Cost &amp; Manufacturing Analysis</td>
<td>100</td>
</tr>
<tr>
<td>Presentation</td>
<td>75</td>
</tr>
<tr>
<td>Acceleration</td>
<td>75</td>
</tr>
<tr>
<td>Skidpad</td>
<td>50</td>
</tr>
<tr>
<td>Autocross</td>
<td>150</td>
</tr>
<tr>
<td>Fuel Economy</td>
<td>100</td>
</tr>
<tr>
<td>Endurance</td>
<td>300</td>
</tr>
<tr>
<td>Total Points</td>
<td>1,000</td>
</tr>
</tbody>
</table>

The goal for the Formula SAE team is to design and develop the race car by end of fall semester. Further, the spring semester should be utilized for testing and detailing. The primary goal of the competition is to finish in the top 40% of all vehicles who finish the race.

During the fall semester, team will be evaluated heavily on documentation, presentation, and performance to ensure maximization of static event points.

Humanitarian projects are intended to address students who have altruistic engineering interests. The humanitarian projects were implemented through petition from students and
have since become a staple in senior design projects. In humanitarian projects, students are tasked with developing their own project statement based on needs they find through research. The objective is to solve a problem while providing a cost effective solution as most humanitarian efforts occur in third world countries. An example humanitarian project problem statement is shown below:

| To become a successful engineer, you must have an ability to create personal, economic, and societal value in your work. The aim of this project is to seek an outreach opportunity and to design and develop a system to meet that need. This challenging problem will require you create a system that both serves the need of a third world country and is affordable to its potential users. This project is unique in that you are able to find your own opportunity and perform the research necessary to identify the need. |
| Ideas must be pragmatic, unique, and have the opportunity to succeed in the market. You are encouraged to seek other opportunities for funding to support you in your efforts. Moreover, this project would be considered a success if a plan for mass production is prepared (or stated) by project completion. |

**Project Type Difference - Requirements**

One of the major differences between industry and non-industry projects are requirements elicitation. We highlight requirements because they are known to play a significant role in the design process, both in industry\textsuperscript{13} and academia.\textsuperscript{14} There are major difference in requirements based on the type of project. On competition projects, students are given a lengthy and stringent set of requirements they must follow. The requirements do not deviate or change throughout the project, which is unlike industry where requirements change and change often.\textsuperscript{15,16} In humanitarian projects, students are given no requirements
and are expected to find project sources and elicit their own set of requirements. This becomes particularly difficult when students are not familiar with the user and the product,\textsuperscript{17,18} which is a common theme in humanitarian projects. Industry projects are in between such extremes where the client provides students with an initial set of constraints, but it is anticipated students will further elaborate and develop those requirements as the project evolves. Requirements education is an important aspect of senior design that will impact students when enter the workforce,\textsuperscript{19,20} given that engineering is a requirements heavily discipline. Thus, it is important that this difference is mentioned as it is often cited by students as the major difference they experience in projects when comparing to others.

**Motivation**

This paper considers motivation as the lens through which we will perform the study. Motivation is considered here as students had a natural inclination to select a specific type of project versus another – an inclination we believe is rooted in motivation. Often, student’s selected project is based on their future goals or personal interests. Consider a case where students want to work for NASA in their professional career. In this instance, a student would put aside their automotive interests and select a NASA project ahead of the formula competition project. To that end, we consider motivation when investigating students’ selection of projects and the changes of motivation throughout the year. Studies have shown a relation between student’s beliefs about themselves regarding skills they possess in engineering and to their future career decisions.\textsuperscript{21,22} Thereby it makes senior design a crucial learning point where students develop new skills in engineering as well as personally. To measure motivation, we utilize the MSLQ.\textsuperscript{23,24} The MSLQ is a robust survey that has been used in various types of learning contexts outside of engineering such as medicine.\textsuperscript{23} The instrument measures five major factors of motivation through self-assessment by the participants. The instrument uses a 7 point Likert scale where students self-identify their motivation level by rating between ”not true” to “very true”. This questionnaire is designed to measure motivation through five individual factors namely cognition value, intrinsic value, self-regulation, presentation anxiety and self-efficacy.
According to Pintrich, these five factors are the foundation to identify motivation. He developed the MSLQ survey to capture the motivation in the best possible form by measuring the described five factors and this has been in use in various researches. This instrument is flexible in that it can be used as a single tool to measure 15 factors using 81 items or factors can be used independently depending on the context of the research.

This research is built on the foundation of MSLQ and motivation factors. One factor that could contribute to motivation is the type of projects students are assigned. Specifically, in industry based projects where an immediate customer (external to the school) exists, will student possess a different type of motivation?

This study measures the above described five factors through MSLQ questionnaire to identify student’s motivation levels when they start and end the capstone design course. These factors tend to change or remain same over a period of time depending on the student’s experiences with their work or their gradual outlook towards a task/goal. Thus this research aims to find answers to the research questions, whether the project choice students make in their senior capstone design course plays role in altering these factors. And if yes, does it help increase motivation over time in the course.

In 2017, out of all the engineering disciplines, mechanical engineering awarded 30,030 degrees securing the first place among all the others in engineering. This not only makes mechanical engineering the most desirable discipline among students but as educators it is important to retain the enrolled students by providing better learning experience during their term in engineering school and provide them with exposure to industry environment through design courses. Cornerstone and capstone design courses are integral part of mechanical engineering as students often describe the interest towards designing as their reason to enter engineering. Academic success of students is often times correlated to individual motivation thus making it important for educators to study student motivation and performance. Senior capstone design course not only prepares students with technical engineering skills but also soft skills like team work, communication, presentation, time management and many more. Thus a yearlong senior capstone design is
a good choice to study student motivation and examine factors which play crucial part in that. This will eventually help the educators to design courses accordingly and prepare students efficiently to face the real world industry environment. Motivation is one incredible factor that serves as a catalyst in any aspect of human success. From technical aspect to research, motivation is one crucial factor that remains constant and differentiates successful people from the rest. Whichever group a person belongs, motivation plays an equal role on both side of the table.

According to Pintrich, motivation is divided into five categories. Cognition Value, Intrinsic Value, Self-efficacy, Test Anxiety and Self-Regulation. The cognitive scale reflects on the student awareness to grasp knowledge and implementation. Cognition is a part of the larger concept of metacognition which describes the ability to set goals, analyze the task and implement it in learning. Self-regulation learning is described as student’s implementation of whatever is learnt to achieve their own set goals. Self-Efficacy is an integral component of the social cognitive theory. Self-efficacy is also regarded as a contributing factor is career motivation. Self-efficacy has been regarded as one of the most important motivation factor for students. Test anxiety is inter related to cognition and emotional balance. For senior capstone design course, presentation anxiety is used. Intrinsic motivation is regarded as the enjoyment one attains in performing a particular task or activity. It is also been regarded to increase creativeness in aspiring students.

**Factor 1: Cognition**

Cognition is defined as a student’s ability to conceive information and to process it through individual’s capability. It also includes processes like analyzing and problem solving, which the industry particularly identifies while hiring engineers. There have been instances when industries feel that students lack self-judgment and problem solving ability when they are hired. There is a continuous effort from both, the educators and the engineering industry to lessen this gap and prepare the students to face the real-world problems ahead of time. This was one of the inspirations for introducing the industry sponsored projects to
the senior capstone design course to give students an opportunity to get a close view of the working environment and methods they need to adapt to before entering the industry.

**Factor 2: Intrinsic Value**

Intrinsic value is the inclination of a student’s participation in activities that involves individual’s curiosity or enjoyment of activity.\(^{35,23}\) Students often tend to lose their interest if they face unfamiliar coursework and this makes senior design a good pick to measure the intrinsic value. This could be well applicable in the case where students take up a competition project but has the inclination towards industry projects or research based projects like a humanitarian project. This not only makes a student lose interest in terms of course work but also affect their motivation level by going through mandatory and unexciting project responsibilities. Thus making one feel out of place and disinterested.\(^{37}\) Intrinsically motivated students have typically considered adaptable for deeper learning when placed in unfamiliar environment.\(^{38}\) It is shown that intrinsic motivation has its support from the student’s sense of relatedness, reasoning, and excellence in particular task.\(^{39,40,41}\) Intrinsic motivation is many times correlated to extrinsic motivation but in this research we focus on the Pintrich’s five motivation factors.

**Factor 3: Self-regulation**

Self-regulation is the student’s ability to organize oneself in term of necessary of course work or assigned responsibilities.\(^{23,37}\) Self-regulation not only adds to individual motivation but for a team project like capstone design, it makes an important criteria for the team dynamics and overall performance of the team. According to a research, self-regulation along with other attributes like soft skills and behavior was found to be contributing to academic success of undergraduate engineering students.\(^{42,43,44}\) This makes it different from the cognitive value as it focuses on the structured method to achieve the team’s goal.\(^{37}\) Self-regulation can sometimes be developed from peers as some studies show peer learning as a significant factor in motivation. The team overall motivation plays an important role in the self-regulation and vice versa. Self-regulation has an impact on the performance. Students have reported that teammate’s individual skills contribute to the
overall success of the team. After multiple analysis, the team at Watchamacallit University and Whatsit University determined that self-regulation had a direct relation with the performance of engineering students.\textsuperscript{45}

**Factor 4: Test/Presentation anxiety**

Test anxiety is the anxiousness experienced by an individual while appearing for a test,\textsuperscript{23} and in this study it is during a presentation. Industry sponsored project teams have more rigorous presentation schedules in comparison to the non-industry project teams at the Florida Tech. This is because the industry sponsored projects are funded by the private or government companies and the representatives keep an update on the project progress on a weekly basis. This gives industry teams more opportunities to present their progress/update to their clients and also to the instructors of the course along with their regular class presentation. Presentation anxiety is also once such tricky factor which can be improved over time by individual efforts. However some students also reported to have anxiety from the freshmen year and it still remains same in the senior year. Thus making it an interesting factor to study by the researchers.

**Factor 5: Self-efficacy**

Self-efficacy is one essential component of social cognition theory.\textsuperscript{46} Self-efficacy defines as one’s ability to complete a task by taking necessary actions towards that goal.\textsuperscript{33,46} Self-efficacy have shown signs of connection between student’s performance and persistence.\textsuperscript{47} Self Efficacy is further described as an amalgamation of these four traits which ultimately leads to completion of a task or a goal,\textsuperscript{33}

1. Previous performance experiences or achievements

2. Past experiences of enjoying the participation or work

3. Peer/ societal persuasions towards something.

4. Physiological scenario
These four traits adds up to define a student’s self-efficacy. The term self-efficacy was introduced in the year of 1997. Various non-engineering fields have reported to use self-efficacy for analyzing social skills, behavior and many more.

**Qualitative Data Collection and Analysis**

Every researcher categorizes their research in one of the three major approaches: quantitative, qualitative and mix method. The researchers in this study have previously conducted analysis using quantitative statistical tool to answer the bigger research question on motivation in senior capstone design students based on their choice of project type. This study will bring more insights into findings of significant factors which were commonly observed in teams or as individuals. Qualitative methods include collecting and analyzing non-quantitative data, such as exit interviews, surveys, observations and focus groups. Qualitative Research Method is often regarded as a meticulous approach to unique sets of data and analysis. In this research approach the researchers have large sets of rich data in textual format. And a case study approach had proved to be a great tactic for data collection in design researches.

There are five major approaches to qualitative analysis, narrative research, phenomenology, grounded theory, ethnography and case study. Narrative research uses stories to collect important finding through narrated life experiences. Phenomenology goes a little deeper into the data by focusing on the minute details of the qualitative data and analyzing them. Ethnography is one of the widely used methods to study culture, through beliefs and processes. Grounded theory is the method incorporated in studies which aims at finding patterns and comparing them to other data sets used in the same study, it’s a constant comparative analysis. Some of the rules that the coders abide by are: they do not code with any pre-conceived notions or ideas and the analysis generated is purely from the data. Case studies have proven to be an excellent approach for the researchers in collecting the rich qualitative data by interviews. Case study is a unique method which provides a structural observation to research items in particular contexts. Thus this study is an amalgamation of all the approaches in decoding the motivation factors in senior capstone
design students. Traces from phenomenology, narrative and grounded theory approach can be observed in the qualitative research method. The generating of themes and coding manual gives the analysis an inclination towards grounded theory approach.

There is always an ongoing fight within a researcher’s mind when it comes to approach a qualitative research method.\textsuperscript{56} Science has always been about providing research findings in numbers and evidences. Very little is praised when it comes to the qualitative data analysis, also the modes of taking up a new qualitative inquiry may feel unfamiliar to the traditional ways of doing research.\textsuperscript{57} However the research team in this study aims to highlight that importance of qualitative research approach. Qualitative research gains fame from finding the unexpected. There have been instances when researchers while conducting qualitative research stumble on things that give a turning point to the entire end result. Senior capstone course is typically administered by the faculty and other university resources, same way the qualitative assessment of the student performance and learning is also locally administered.\textsuperscript{58}

**Exit Interviews**

Exit Interviews is one of the methods of collecting data for the qualitative research. Exit interviews have been used in other design setting to inquire on student experience in a course, program, or even post-graduation. The purpose of exit interviews is to collect data that otherwise would be missed if interviewee was inquired through a survey. Further, the interview process allows interviewees to explain their thoughts in greater depth and allow for deviation to other tangential, yet relevant discussions.

Exit interviews can be a one on one interview session or a group interview. Many times exit interviews can also be conducted through emails or other technology platforms.\textsuperscript{58} Exit interviews can be structured or semi-structured.\textsuperscript{59} In structured interviews, the interviewee asks the same set of planned questions to participants. There is no follow up questions based on the responses received from the subjects. Structured interviews have been proved to advantageous in many fields other than engineering.\textsuperscript{60} Global top business companies use this method to collect invaluable feedback from their employees to improve their work
environment and team dynamics. Exit interviews are often conducted by HR and managers of companies as a platform where existing employees or departing employees share their good and bad experiences, suggestions, concerns and valuable information for the improvement of environment or approach. Employees when leaving the organization participate in exit interviews as their last duty towards their respective company. Additionally, they are useful for gathering student feedback on programs, college, and experiences.

For this study the research method approached by the team was conducting the exit interview with the senior capstone design students. This interview was conducted after their final project showcase of senior design and the class was near graduation day. This interview focused on finding the motivation factors in the student during their time in senior capstone design course. The questions framed by the research team aimed at finding the motivation factor and the time frame in which they were most significant and played a vital role in their motivation to complete the course. A structured interview protocol wasn’t developed before this study, hence this qualitative data analysis by exit interview will serve as the interview protocol for upcoming researches. Some of the questions aimed at finding the anxiety, self-regulation and personal choices of project selection.

The students were just introduced to the exit interview by giving them a background about how the interview would go and their identity would be anonymous whenever the recording would be used for school purpose. The interview also aimed at getting essential feedback from the students for improvement of the course for future years to come. The same cohort of students had participated in the quantitative MSLQ survey with their class which aimed at finding their motivation at various stages in the project development phase.

**Coding Scheme Data**

The qualitative is considered rich data in many aspects by the researchers as it provides with immense information, interpretations and perspectives. This also tricks the researchers into not falling in the trap of generating results based on one’s belief. To eradicate that dead end, the study uses the two rater method, where the two researchers
independently read each transcripts and derive possible codes, categories and themes pertaining to factors that are either commonly observed or striking to a particular trait observed in a team. In a quantitative research the significance of the results obtained is on the instrument construction whereas in the qualitative research, the researcher is the instrument. Thus making the qualitative researcher be in charge of the credibility of the findings. Researchers must approach a positivist approach and present the facts not get inclined by one’s perspective about certain context. A thematic approach defines the method of re-analyzing the data multiple times. Development of coding scheme typically uses holistic approach in generating codes and categories around the themes emerging from the qualitative data. One popular way of approaching the qualitative data is the thematic analysis where the researchers aim at deriving possible themes from data and codes pertaining to those generated themes. There are instances where the coders are overwhelmed with the data and that might lead to inconsistencies in categorizing the codes, to solve that the researchers in this study have used the technique of have primary coders and master coders.

**Reliability Tests**

Interrater reliability is an important subject of discussion when it comes to interpreting qualitative data as it involves multiple people with different perspective and experiences. Reliability is a method adopted to check the quality of the findings and verify whether both the coders on this research have certain amount of agreement. Inter coder reliability method is often adopted to check the agreement between two coders on the generated coding scheme. Inter-coder reliability is frequently referred to as interrater reliability. There are various reliability indexes that could be used to calculate the reliability of the codes between two rater or individual raters. For this particular research, Cohen Kappa reliability index was used. Cohen’s kappa, k coefficient measures the agreement frequency between two raters. A coefficient of greater than 0.80 to 1 is considered almost perfect agreement. Kappa coefficient ranges from -1 to +1, and it is one of the commonly used statistic approach to test reliability. Cohen’s kappa is performed using the following formula.
\[
K = \frac{P_o - P_e}{1 - P_e}
\]

Where, \( P_o \) = Simple agreement among raters

\( P_e \) = Agreement is attributed to chance

After the calculation of agreement by the raters, the results can be interpreted according to the kappa coefficient value obtained as follows.\(^7\)

<table>
<thead>
<tr>
<th>Coefficient value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–.20</td>
<td>None</td>
</tr>
<tr>
<td>21–.39</td>
<td>Minimal</td>
</tr>
<tr>
<td>40–.59</td>
<td>Weak</td>
</tr>
<tr>
<td>60–.79</td>
<td>Moderate</td>
</tr>
<tr>
<td>80–.90</td>
<td>Strong</td>
</tr>
<tr>
<td>Above.90</td>
<td>Almost Perfect</td>
</tr>
</tbody>
</table>

**Summary of Research Gaps and Findings**

This thesis aims at finding the motivation factors affecting the senior capstone design students, for this we chose the quantitative and qualitative research methods. The aim is to find which factors had an influence during a particular period in the senior capstone design course. Quantitative data will thus provide student’s motivation scale by their self-assessment through MSLQ survey and the qualitative by the exit interview conducted for this research. Qualitative data analysis thus aim to be the framework for all the future analysis to by developing a code book based on the interviews conducted with the senior
capstone design students. The thesis will provide findings from the mixed method analysis and the results that the team obtained from the study.
Chapter 3
Research Methods

This research was performed through use of mixed method design. Case studies are effective at addressing exploratory questions such as “how” and “why” a phenomenon occurs. Case studies are a popular experiment type in both academic and corporate settings\textsuperscript{26,28} Since the objective of this research is exploratory in nature as we attempt to identify differences in motivation and project types, a case study approach is used.

Quantitative Instrument

The instrument used in this study combines both the MSLQ survey and student’s assigned project detail. Students were given the adapted version of MSLQ survey which consisted of 43 questions to self-record their motivation level on a 7 point Likert scale. Five factors were studied within the student cohorts: cognitive value, self-regulation, presentation anxiety, intrinsic value, and self-efficacy. The MSLQ survey records the five factors of motivation through self-assessment questions about how a student feels about aspects of the particular course and whether it changes or not.

To measure the five factors that contribute to the motivation, the research team in this study used the adapted version of MSLQ survey to determine the motivation level at two instances in the senior capstone design course, in the beginning of the fall semester and at the end of the spring semester. The 43 questionnaire used for this study is shown in appendix A. Table 4 shows number of questions related to each factor defining overall motivation.
Table 4: Motivation factors in MSLQ survey

<table>
<thead>
<tr>
<th>Motivation Factors</th>
<th>Number of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Value</td>
<td>12</td>
</tr>
<tr>
<td>Self-regulation</td>
<td>9</td>
</tr>
<tr>
<td>Intrinsic Value</td>
<td>9</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>9</td>
</tr>
<tr>
<td>Presentation Anxiety</td>
<td>4</td>
</tr>
</tbody>
</table>

Qualitative Instrument

The instrument used in the qualitative study is the structure exit interview. Exit interview plays a great role in findings in a research method, which are sometimes lost in various other methods of data extraction. The inspiration to do so comes from various studies done depicting the importance of qualitative data analysis and how that it proves a bonus to support the quantitative work done in the same field. The exit interviews were formed through the use of a protocol study. This was performed to ensure the interviewee had an opportunity to triangulate any responses and provide prompts if necessary.

While other qualitative instruments were considered, interviews were considered to be the optimal choice. In an interview setting, interviewees are free to respond to questions in an open manner and can seek corroboration from their team mates. Additionally, in the interviews performed here, the students could opt for an additional interview session that was one-on-one.
Study Subjects

The instrument was administered to 188 senior design students studying mechanical engineering over the three year cohort period (2013-14, 2014-15, 2016-17). All students in the course where seniors enrolled in Mechanical Engineering with an expected graduation at the end of the year. The analysis was performed with the data collected from three cohorts of senior design students who volunteered for the study during the beginning of the fall and at the end of the spring semester. Table 5 details the project and gender data of the subjects.

Table 5: Subjects Gender and Project Selection Information

<table>
<thead>
<tr>
<th></th>
<th>Industry Sponsored</th>
<th>Non-Industry</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>55</td>
<td>92</td>
<td>170</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>100</td>
<td>188</td>
</tr>
</tbody>
</table>

Data Collection: Survey

Data was collected twice during the academic year: at the beginning of the fall semester and the end of the spring semester. Students were asked to volunteer for this study by participating in the MSLQ survey. The MSLQ survey tool used in this study is an adapted version of Pintrich’s MSLQ. The survey consisted of 43 questions designed to identify the motivation level as it related to senior design. For instance, since senior design does not include tests or examinations, questions relating to test anxiety were converted to presentation anxiety. The adapted version of the MSLQ used in this study is shown in appendix.

The questions in the survey aim at addressing the five factors contributing to the overall motivation of an individual. Cognitive value, self-regulation, presentation anxiety, intrinsic
value and self-efficacy. As shown in the layout of MSLQ survey in appendix, the questions addressing each factor is highlighted. For example, Q1. “I prefer class work that is challenging so I can learn new things”, represents intrinsic value for calculating an individual student’s motivation. Similarly the other questions aims at attaining the best possible value for each factor defined in the motivation.

**Data Collection: Interview**

Exit interviews were conducted after the completion of senior design course, a week before the graduation. The purpose of conducting the exit interviews was to gain a deeper insights on the experiences, especially the challenges and motivating factors the students encountered during their time in the year-long senior capstone design course. Interviewing is widely viewed as a tool to collect potential qualitative data and in identifying complex attributes contributing to the purpose of conducting interviews. In this research a structured form of exit interview was performed. The only constant variable was the time. Thirty minute interview was performed with all the teams. Interviews were conducted as focus groups. Each team was interviewed for thirty minutes with the structured interview format. In the previous research, the same cohort of students participated in the quantitative MSLQ survey conducted twice a year, in the beginning of the senior capstone design in fall and at the end of senior capstone design course in spring. Students identified their motivation level at two instances by rating themselves on a 7 point Likert scale. To get a closer view of the factors affecting motivation levels at various stages of the capstone experience, our research team conducted exit interview with each team with questions pertaining to their team balance their individual setbacks and achievements and their overall experience from the design course. The exit interview questions were formulated by the research team working in the engineering education field and based on their research on motivation in engineering students.

Each team was interviewed for 30 minutes by the team of researchers involved in this study. A set of 19 questions were articulated and agreed on by the research team. Each team interviewed with same set of questions. The researchers in this team have conducted
various research on student motivation in senior design in the past and have observed trends and that played a major role in formulating the interview questions. Responses were collected in audio recordings from each team. Audio tapes includes input from every member who participated in the interview session with their identity hidden. A total of 9 senior design teams participated in the interview session scheduled during their capstone course class hours. The collected data was later transcribed into textual format. Appendix A shows the set of 19 questions formulated for this study. Table 6 highlights a select few questions that were inquired during the exit interviews.

<table>
<thead>
<tr>
<th>Table 6: Exit Interview Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were you anxious entering senior design?</td>
</tr>
<tr>
<td>What factors enabled you to do well in the course?</td>
</tr>
<tr>
<td>Do you feel more confident in your ability as an engineer having completed senior design?</td>
</tr>
<tr>
<td>Do you feel you would have learned more on a different project than your current choice?</td>
</tr>
<tr>
<td>Do you wish to continue your education after graduation? If so, did senior design play any role in this?</td>
</tr>
</tbody>
</table>

The participants in this study are the senior capstone design students at Florida Tech graduated in the year 2018. The exit interviews were conducted with each team at different timings. The team as a whole participated in the exit interview survey. The senior capstone design course has a total of 9 teams. 4 industry sponsored teams and 5 non-industry teams. A set of 19 questions were framed by the experienced research team working in engineering education for a prolonged period of time. The research team in the past analysis has observed certain trends in motivation and that laid the framework of the exit interview questionnaire. Each team in the senior design course were asked the same set of questions for a period of 30 minutes. Time was limited to 30 minutes in this study for each
interview. And for further feedback and answers the students were provided with contact
details of the researcher team to reach out after the interview. All the answers were
recorded on an audio tape and further transcribed. Identities were kept hidden, however the
transcribed data differentiates between male response and female response for future work.

Table 7: Participants in the Qualitative Exit Interview

<table>
<thead>
<tr>
<th>Senior Capstone Design Teams in Exit Interview</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag Car</td>
<td>11</td>
</tr>
<tr>
<td>Baja</td>
<td>11</td>
</tr>
<tr>
<td>Formula</td>
<td>17</td>
</tr>
<tr>
<td>NASA JPL</td>
<td>21</td>
</tr>
<tr>
<td>Lockheed Martin</td>
<td>6</td>
</tr>
<tr>
<td>Navy</td>
<td>6</td>
</tr>
<tr>
<td>Harris</td>
<td>5</td>
</tr>
<tr>
<td>Outreach 1: Gray Water</td>
<td>7</td>
</tr>
<tr>
<td>Outreach 2: HAYA</td>
<td>6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>90</td>
</tr>
</tbody>
</table>

Quantitative Data Analysis

To address the research questions posed, multiple statistical analysis methods are
employed. ANOVA single factor and t-tests are performed on the data collected from a
total of 188 students during their respective senior capstone design course. The statistical
analysis compared student motivational factors to their selection of an industry sponsored
or non-industry project. The objective of the analysis is to answer our research question by
examining how student’s choices of senior capstone design projects affect their motivation
throughout the course and how this motivation changes during their final year in the
engineering school. The statistical analysis considers p<0.05 to be statistically significant.
However, values of p<0.10 are maintained for discussion purposes. The reason being, for statistical significance of the data analysis performed the researches chose 0.10 as the desirable p value to validate the findings obtained from the analysis.

ANOVA is used initially to determine if there are differences in student motivation between the three project types (industry, competition, humanitarian). The analysis considered the motivation at the beginning (fall), end (spring) and change from beginning to end (delta). Factors that demonstrated a difference in the ANOVA were further segmented into industry and non-industry projects so a paired t-test may be performed.

**Qualitative Data Analysis**

The data to be analyzed is nine exit interviews with senior design students to understand their motivation at various stages of project development and what significant factors played a role in that. The researchers begin with codes and theme generation for developing structured interpretation of the qualitative data.

Coders: The coders in this study are research graduate students and professor researching in design engineering and education with experience of working on motivation in engineering students. Hence that helped the team in forming the coding scheme as they observed certain trends when conducting the quantitative analysis. Using the exit interview transcripts, the two coders coded the transcripts into possible codes. The coders were trained using the coding manual listed in methods of coding.

Coding: The transcripts were analyzed several times before developing the final coding scheme. Development of the coding manual was an iterative process. The two qualitative researchers in this study served as the primary coders and the other two authors served as the master coders in finalizing the scheme and solving any arising discrepancies. The two primary coders coded the entire qualitative data into codes in the first round of analyzing the data. They codes the transcripts individually and then as a team, this process was repeated several time before finalizing the coding scheme with the themes. The coders used
RQDA tool by RStudios in analyzing the qualitative data and generating possible codes from each transcript. The second round of analyzing was revisiting the transcripts and finding possible themes and categories aligning with the generated codes. The master coders on the team also analyzed the data from transcripts before finalizing the themes, categories and codes. The end part of coding was the agreement on the codes to be included. This also gave the reliability coefficient of the scheme. Thus the coding scheme development is an iterative process and this served as the framework for more possible codes and themes. After visiting the qualitative data several time individually and as a team simultaneously, the team was able to generate themes for this study, The reliability was also measured every time the coders notice agreement on transcripts data.

**Mixed Methods Data Analysis**

A mixed method study involves collecting and analyzing both the qualitative data and the quantitative data. This method is typically approached by the researchers to obtain a broader perspective on the research questions. Use of mixed method studies is getting popular in healthcare and other fields. It is often assumed that quantitative statistical analysis is mere a numerical representation and qualitative is more of wider range with many possibilities of open ended solutions. Thus for a wider and better approach for this research, we selected a mixed method study. It is proved that a mixed method study can derive findings and conclusions which a single method cannot. It was observed that when performing the two research methods, the researchers overcame their preconceived notions and find results which provide not only a strong result but also helps researcher to develop a deeper reasoning for the subject. In this mixed method study, the aim is to use the qualitative and quantitative research techniques to examine the motivation levels in senior capstone design students. Qualitative data is collected to further examine the results of the quantitative. This provides additional input that could shed light on why some of the quantitative results were affected by certain motivation factors. This might be time consuming but for this thesis it is the best approach as we were able to compare the results and solve the research questions we initially hypothesized. Mixed method approach helped
us getting a closer view to insightful journey of senior capstone design student and team. We came across some highlighting factors which could have been lost in a single approach. Thus mixed method study in this research helped us better answer the questions we aimed at exploring in the first place.
Chapter 4
Results

The results will discuss both the ANOVA and t-tests results obtained from the statistical analysis. ANOVA single factor analysis and t-test are some of the most commonly used statistical tools in quantitative research method.

The exit interviews were transcribed by the research team. The two researchers on this team later developed a coding manual individually and then later as a team. The development of the coding manual and the coding scheme is an iterative process. After the two raters agreed on the coding scheme for the qualitative exit interview that was conducted in the end of the spring semester for the year 2017-2018 senior capstone design students, three themes were generated. The three theme were Selection, Process and Results. In total 69 codes were divided into various categories assigned under each theme. Appendix D shows all the themes, categories and codes developed from this qualitative research.

Through analysis of the qualitative data, a pattern emerged whereby students discussed their experiences before project (the process of selecting the project), during the project (the design process), and after the project (when they completed the project and delivered a final solution). To that end, the coding scheme was segmented into the three said areas whereby each one was designated as a theme.

ANOVA Single Factor Analysis

The five main factors contributing to student’s motivation were analyzed using ANOVA and t-tests were appropriate. The ANOVA analysis assisted in determining where differences between responses were observed.
Results obtained from the statistical analysis revealed that cognition was lower in students involved in the industry projects in the beginning of the academic year i.e. the fall semester in comparison to student in competition and humanitarian project type. Table 8 shows the results obtained from the fall semester data with respect to the cognitive value. However delta cognitive value increased significantly in the industry group with a value of 0.19±0.89 in comparison to other teams. Interestingly, the industry projects were the only type to reveal an increase in cognition throughout the semester. However, it should be noted that industry projects started the lowest of the three during the fall semester.

Table 8: Fall and Delta Cognitive Values

<table>
<thead>
<tr>
<th>Teams (Cognitive Value)</th>
<th>Fall $x \pm \sigma$</th>
<th>Delta $x \pm \sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>5.24±0.67</td>
<td>-0.01±0.97</td>
</tr>
<tr>
<td>Industry</td>
<td>4.96±0.72</td>
<td>0.19±0.89</td>
</tr>
<tr>
<td>Humanitarian</td>
<td>5.35±0.62</td>
<td>-0.29±0.95</td>
</tr>
<tr>
<td>p-value</td>
<td>0.013</td>
<td>0.087</td>
</tr>
</tbody>
</table>

As shown in Table 9, the analysis revealed that competition team had higher intrinsic value in the spring semester. Industry and competition teams did not have a significant difference in their average value in the spring semester. While industry teams showed a notable increase when compared to the delta value with other teams, it was midway to competition and humanitarian teams. No differences were observed between teams for intrinsic motivation in the fall semester.
Table 9: Spring and Delta Intrinsic Motivation Values

<table>
<thead>
<tr>
<th>Teams (Intrinsic Motivation)</th>
<th>Spring $\bar{x} \pm \sigma$</th>
<th>Delta $\bar{x} \pm \sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>6.24±0.61</td>
<td>0.57 ± 0.88</td>
</tr>
<tr>
<td>Industry</td>
<td>5.98±0.69</td>
<td>0.32 ± 0.69</td>
</tr>
<tr>
<td>Humanitarian</td>
<td>5.85±0.84</td>
<td>0.25 ± 0.54</td>
</tr>
</tbody>
</table>

p-value $0.009$ $0.058$

As shown in Table 10, Self-Efficacy is higher in competition teams in the spring semester. Industry teams were midway in self efficacy in the spring semester compared to the rest of the teams. The delta value for the industry teams was midway to competition and humanitarian indicating the competition teams had the highest self-efficacy in the spring and delta values. No differences were observed between teams for self-efficacy in the fall semester.

Table 10: Spring and Delta Self Efficacy Values

<table>
<thead>
<tr>
<th>Teams (Self-Efficacy)</th>
<th>Spring $\bar{x} \pm \sigma$</th>
<th>Delta $\bar{x} \pm \sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>6.17±0.62</td>
<td>0.73±0.90</td>
</tr>
<tr>
<td>Industry</td>
<td>5.92±0.67</td>
<td>0.51±0.80</td>
</tr>
<tr>
<td>Humanitarian</td>
<td>5.58±0.84</td>
<td>0.32±0.66</td>
</tr>
</tbody>
</table>

p-value $0.0002$ $0.048$

As shown in Table 11, the results revealed that industry sponsored projects possessed lower self-regulation in the student cohorts in the beginning of the fall semester. Competition teams had the highest self-regulation when entering senior capstone design
course. No differences were observed between teams for self-regulation in the spring semester and deltas between fall and spring.

**Table 11: Self-Regulation Values during Fall Semester**

<table>
<thead>
<tr>
<th>Teams (Self-Regulation)</th>
<th>Fall $\bar{x} \pm \sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>5.20 ± 0.83</td>
</tr>
<tr>
<td>Industry</td>
<td>4.80 ± 0.85</td>
</tr>
<tr>
<td>Humanitarian</td>
<td>5.05 ± 0.69</td>
</tr>
<tr>
<td>p-value</td>
<td>0.013</td>
</tr>
</tbody>
</table>

As shown in Table 12, the presentation anxiety showed lower among industry team students in the beginning of the academic year. Humanitarian teams had the highest presentation anxiety in the fall semester. No differences were observed between teams for presentation anxiety in the spring semester and deltas between fall and spring.

**Table 12: Presentation Anxiety Fall Semester**

<table>
<thead>
<tr>
<th>Teams (Test-Anxiety)</th>
<th>Fall $\bar{x} \pm \sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>4.33 ± 1.70</td>
</tr>
<tr>
<td>Industry</td>
<td>3.76 ± 1.64</td>
</tr>
<tr>
<td>Humanitarian</td>
<td>4.55 ± 1.48</td>
</tr>
<tr>
<td>p-value</td>
<td>0.048</td>
</tr>
</tbody>
</table>

A summary of the results is shown in Table 13. The table highlights the statistically significant findings revealed through the ANOVA analysis.
Table 13: Statistically Significant Results of ANOVA Analysis

<table>
<thead>
<tr>
<th>Factor</th>
<th>Time of the survey</th>
<th>Notable observations on project groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognition</td>
<td>Fall</td>
<td>Industry teams (4.96±0.73) had lower cognition than competition teams (5.24±0.67) in the beginning of the fall semester</td>
</tr>
<tr>
<td>Self-Regulation</td>
<td>Fall</td>
<td>Industry (4.80±0.85) had lower self-regulation in the beginning of the fall semester</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Fall</td>
<td>Industry (3.76±1.64) showed lower anxiety in the beginning</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>Spring</td>
<td>Competition (6.24±0.61) had higher intrinsic value among all teams</td>
</tr>
<tr>
<td>Efficacy</td>
<td>Spring</td>
<td>Industry (5.92±0.67) had midway self-efficacy</td>
</tr>
<tr>
<td>Cognition</td>
<td>Delta</td>
<td>Industry (0.19±0.89) increased in cognition</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>Delta</td>
<td>Industry (0.32±0.69) intrinsic value increased about midway to other teams</td>
</tr>
<tr>
<td>Efficacy</td>
<td>Delta</td>
<td>Industry (0.51±0.80) efficacy increased about midway at the end</td>
</tr>
</tbody>
</table>

Mean Comparison Results

To further analyze the ANOVA results, a t-test is performed to compare project types to fall, spring, and deltas in motivational factors. The factors in Table 14 shows the statistically significant results that reject the null hypothesis between industry and non-industry teams. Non-industry teams are a combination of the competition and humanitarian teams.
Table 14: Means and Standard Deviations of Statistically Significant Factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>Industry Teams x̅ ± σ</th>
<th>Non – Industry Teams x̅ ± σ</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall-cognition</td>
<td>4.96±0.72</td>
<td>5.30±0.65</td>
<td>0.004</td>
</tr>
<tr>
<td>Fall-self-regulation</td>
<td>4.80±1.64</td>
<td>5.12±0.76</td>
<td>0.005</td>
</tr>
<tr>
<td>Fall-anxiety</td>
<td>3.76±1.64</td>
<td>4.46±1.60</td>
<td>0.017</td>
</tr>
<tr>
<td>Delta-cognition</td>
<td>0.19±0.89</td>
<td>-0.15±0.96</td>
<td>0.079</td>
</tr>
<tr>
<td>Delta-self-regulation</td>
<td>0.09±1.00</td>
<td>0.39±0.97</td>
<td>0.061</td>
</tr>
</tbody>
</table>

Senior Capstone Design Coding Scheme

Theme 1: Project Selection

The first theme that the research team generated was the selection process for the senior design. This theme describes the initial phase of selecting the capstone project by the students. The team also found the following codes to have played an important role in the project choices that they had made. The codes were later divided into the categories. The categories that indicated their selection process were personal factor, previous experience, current goals, future goals, challenges/limitations that the student came across in the beginning of the fall of semester. Table 1 gives a detail breakdown of the theme, categories and codes for the selection process.
The above shown codes have been observed by the researchers at multiple instances in the exit interviews conducted with the senior capstone design project teams. Student’s personal experiences, goals and environment have played a critical role in their decision when they entered the senior capstone design course.

One of the code in the selection process is competition. Teams reported that the desire to compete and feeling of being in a competitive environment is what motivated them to select the competition project reflecting what thoughts and decision making factors influence students while making their selection of the capstone design project. Some of the quotes by the students show how competition had been an important factor.

Extracts from the interview:

- “A competition project, it forces you to like be better. You have to bend the rules a little bit. It pushes you to do the best that you can, and make your car competitive”

  Drag team member
• “I mean, competitions always make you better, so if you are afraid of competitions, you’re not improving yourself. So life is competition. Everything is competition. So if you agree to go with it, every step you go forward, you gain more knowledge, you more ability. And as you believe in yourself more. Yeah.” 

  **Drag Car team member**

• “And then because it's a competition and you also want to do good in the competition, because it's like the name of the school is at stake and things like that” **Baja team member**

Another instance where students reported to have selected certain project because of having a potential job opportunity with the project they were working on. Some industry projects had been an influence on their selection as it seemed to align with their future goals.

Extract from the interview:

• “I believe it is a project that will shape a lot your resume as it's your first professional experience. So it depends a lot whether you want to do afterwards. So if you want to get hands on and you're going to work on something.” **Formula**

• “I was motivated by a potential job opportunity and networking with a company.” **Navy**

• “Working with NASA and any of its branches would be like a dream come true for me. So when I saw that NASA JPL was an option, I obviously wanted to work with them.” **NASA JPL**

The above shown extracts from the exit interview gives a detailed look of the student’s response when asked about their project selection phase. It provides with an in depth look about the experiences, emotions and motivation the students had at the beginning of the fall
semester when they had just begun knowing the problem statement and their team members.

**Theme 2: Project Process**

Theme 2 identifies the factors that had played a vital role in their motivation while working on the project. This gives an insight to the phase where student’s had been completely involved in their respective projects. This theme further divides into categories where student’s point out more important and specific factors and people that lead to their success/ failure. This theme also highlights the challenges and motivations they faced as a team. Thus it not only gives information about their individual experience but also how they felt working on a team and the project.
Figure 2: Coding Items for Process Theme
Some of the codes the research team identified in the selection process were the feeling of anxiousness, team dynamics, guidance they received from their instructors and the gsa’s to their particular projects.

Extract from the interview regarding Anxiousness:

- “I’d say yes. I did not know anything about cars. So to go into an automotive project and be in the team lead of that, it was a little stressful. A little anxious.”  
  
  Baja team member

- “I was a little nervous, yeah, at the beginning. Like in the very first weeks. But later on it got a little bit--I got used to it. But the anxiousness doesn't go away.”  
  
  Humanitarian team member

- “I personally was quite anxious not knowing that I actually even wanted to do mechanical engineering.”  
  
  Nasa JPL member

Team members from the industry team as well as non-industry teams have reported that they were anxious. Some were anxious while entering senior design and some reported to have had that feeling throughout the course. This indicates one of the important factors of motivation, i.e. anxiety. Anxiety seems to be a common factor in the senior capstone design students. It was observed at 37 different instances in the interviews by 9 senior capstone design teams.

Extract from the interview regarding Team Dynamics:

- “Everyone just did what they needed to do. Everyone put the effort in. And we didn't have to pull teeth to get people to do effort, which was a good thing.”  
  
  Harris

- “The only deterrent is a lot of the team dynamic roles took away from me to be able to get hands on with the robotics more intensely”  
  
  NASA JPL
Team dynamics indicated the internal working of the individual team which is hard to capture in any quantitative survey. Exit interview played a major role in highlighting those important team situation which never come across in surveys but have had a major role to play in the overall performance of the team. Some teams seems to have the perfect balance with the team lead and members, they showed how individual effort by each team member proved to be a winning factor for them. However the same factor also showed to have negative impact on the team members. NASA JPL was one of the biggest project in that year and had sub teams larger than most other industry and non-industry teams. They struggled with team dynamics and team size. This is one important code that highlights some of the team situation that exits.

Extract from the interview regarding Guidance:

- “I think we as a team especially were yearning for a lot of guidance.”

  Humanitarian team

Guidance from the instructor and GSA was reported to have affected many team members. Some also elaborated why they needed more guidance in terms of course work and how the process of designing in general works. Guidance from the people involved in the senior capstone design course indicated being a morale up lifter for many students who needed direction.

**Theme 3: Results**

The last and final category of the senior capstone design was the results. Results focused on the reflection from course. It also showed some of the future goals and skills students reported. Student reflected on the how their journey in the senior capstone design course influenced their goals. They also reported on their decisions, how it turned out for them as individuals.
Extract from the interview regarding Learning Quotient:

- “I don't think I would have learned more on a competition project simply because based on my reasoning for choosing an industry project was to do something new or to solve a real-world problem for a company.” *NASA JPL*

When asked about how much students had gained from the course, the responses were mixed. Some teams seemed to have been satisfied with the overall experience. However
many reported that it could have been better. It could be because of the choices they made in the beginning or some factors which hindered their overall expectation from the course.

Extract from the interview regarding Change Project:

- “But there are definitely factors that would make me consider going industry over competition.” Baja team member.

Baja team member

Students have also reported that if given a chance to go back and change project, they would and would not. There was a mixed response on whether they would change the project.

This theme had various important factors to consider on. Students reported on the reflection, their plans to go to grad school and industry. It highlighted their reflection on the senior capstone design course. Students overall reported on having good experience from the course. And teams who did not, however mentioned why it was so. Reasons being personal project choices to surrounding factors.

**Interrater Reliability of Coding Scheme**

To calculate the reliability of the coding scheme developed by the research team in this study, the approach taken was the interrater reliability method using Cohen Kappa reliability coefficient. After the development of the coding scheme by the research team, the two raters then calculated the interrater reliability by re-reading the 9 exit interview transcripts before finalizing the codes, and alongside calculating the number of time they agreed on a code to include or exclude. And to solve any discrepancies faced during that process, the master rater in this study would come up with a decision. The interrater reliability using the Cohen Kappa method was calculated to be 0.99 which is higher than the suggested 0.75.

Table 4 shows the frequency of codes observed in the qualitative data analysis. Selection process have five sub categories, which includes personal reasons, previous experiences,
current goals, future goals and challenges. On analysis it is found that personal reasons had most significant impact on the selection of senior capstone design project. It is observed 87 times in the entire data collected from exit interviews from the senior capstone design teams. Process has three categories, people, challenges/motivators and project requirements. “People” is the highly recorded factor to have an impact in the process of senior capstone design course. It is observed the highest among the three, 127 times. Challenges/Motivators was 85 times recorded in the analysis. Results has three categories, future, skills and reflections. Reflections is highly observed category with eight individual codes. It is recorded 152 times in the entire analysis. Thus it gives us a comparison between various factors that could have possibly played a role in change in motivation in senior capstone design students.

**Table 15: Code Frequency Table**

<table>
<thead>
<tr>
<th>Codebook</th>
<th>Totals</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal</td>
<td>87</td>
<td>14.8%</td>
</tr>
<tr>
<td>Previous Experience</td>
<td>21</td>
<td>3.6%</td>
</tr>
<tr>
<td>Current Goals</td>
<td>19</td>
<td>3.2%</td>
</tr>
<tr>
<td>Future Goals</td>
<td>24</td>
<td>4.1%</td>
</tr>
<tr>
<td>Challenges</td>
<td>15</td>
<td>2.6%</td>
</tr>
<tr>
<td>Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People</td>
<td>127</td>
<td>21.6%</td>
</tr>
<tr>
<td>Challenges/ Motivators</td>
<td>85</td>
<td>14.5%</td>
</tr>
<tr>
<td>Project Requirement</td>
<td>6</td>
<td>1.0%</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future</td>
<td>15</td>
<td>2.6%</td>
</tr>
<tr>
<td>Skills</td>
<td>37</td>
<td>6.3%</td>
</tr>
<tr>
<td>Reflections</td>
<td>152</td>
<td>25.9%</td>
</tr>
</tbody>
</table>
Chapter 5
Discussion

The results obtained from this research aim to improve the project offering by schools and educators. The aim was to find which factors affect the motivation, results collected from the analysis aim to improve those and provide educators with a deeper insight.

ANOVA Single Factor Analysis for Senior Project Groups

The results obtained from our analysis state that cognition was higher among the competition teams compared to industry teams in the fall semester. Industry teams (4.96±0.73) had lower cognition in the beginning of the fall semester when they were introduced to the project with a significant F statistic value of 4.44. While the cognitive values for all teams showed no difference during the end of the spring semester, there were differences observed during the semester. The delta cognition value for industry teams increased (0.19±0.89) indicating that the teams develop the ability to solve and analyze problems throughout the course of senior capstone design. This could be attributed to their experience working on a real-world industry project, thus increasing motivation. On the other hand, the non-industry teams showed a decrease cognitive value. Given that cognitive value measures the ability of a student to conceive information and later process and analyze it toward a particular task, it is not surprising that non-industry projects experienced a decrease in this. Industry projects are typically well defined as the students must design and develop a system to meet the industry sponsor’s needs. Conversely, the humanitarian and competitions teams have a significant amount of design flexibility, thus there is a higher load on the team to develop their own information, compared to processes and analyzing the information given to them by a sponsor. For instance, consider humanitarian where students have to identify a market and a solution to fit a need in said market. There is no information given to students initially for them to analyze, rather they are expected to go and actively find potential opportunities. The non-industry teams
exhausted more time finding information compared to analyzing it from the start. Two weeks into the fall semester, the industry sponsored teams were already processing and analyzing information.

For the intrinsic factor, results show that the competition teams had a higher intrinsic value (6.24±0.61) compared to the industry and humanitarian teams in the spring semester. The delta intrinsic value shows that industry teams went up about midway indicating that the intrinsic motivation is eventually developed and it rises over the semesters. The F statistic for spring intrinsic value is 4.85 which is higher than F critical (3.0447) thus making it a significant result.

Self-efficacy is the conscious awareness of successfully completing any task based on individual’s ability. When analyzed the self-efficacy among the senior students of mechanical engineering, it shows that industry teams were midway in self efficacy in the spring semester. The delta value for self-efficacy rose to midway. Industry teams showed an increase in self efficacy.

When asked to evaluate themselves on the MSLQ survey, our analysis shows that industry team students exhibited lower self-regulation in the beginning of the senior design capstone course. Competition teams however showed the highest self-regulation. This could be interpreted to the fact that competition team students have previously involved themselves in similar task during their junior design or in SAE clubs, which makes them better aware of the tasks they need to do or the path to follow. Industry teams on the opposite side, face a completely new environment of the real-world industry problems making them feel less motivated in the beginning of the semester compared to the non-industry teams.

Presentation anxiety refers to the nervousness student encounters during presentation. Our results show that industry team students had the lowest presentation anxiety among all the other teams. The Fall data states that they were confident to present in comparison to students of the other teams.
Thus from the ANOVA analysis performed on the cohorts of senior design students, the industry teams started their senior capstone design course with lower cognition and lower self-regulation than the non-industry teams. They also started with lower presentation anxiety indicating they were confident and motivated to present to their client and take up the task of solving their problem statement. Industry teams showed an increase in their cognition and self-efficacy near completion of the course competition team among all had the highest intrinsic motivation by the end of the academic year. Industry teams rose to midway by the end of the spring semester with an increased cognition, self-efficacy and intrinsic motivation in comparison to competition and humanitarian teams. Thus it can be stated that involvement with an industry project helped students to gain confidence and increase motivation over the time as they could feel a connection to the industry environment and better equipped to face such a challenge in future.

**Mean Comparison of Projects**

The aim of the t-test was check our null hypothesis that there is a difference in motivation depending on the type of projects students select for their senior year. For this research the p-value <0.05 was taken as desirable. Results show that industry teams started with low cognitive value, self-regulation, and presentation anxiety in the fall semester with significant p values. The non-industry teams exhibited higher motivation at the beginning of the semester. The delta value shows that industry teams increased in cognition and self-regulation during the duration of the course. Thus indicating that all the teams started at different levels but throughout the course of senior capstone design developed similar motivation. This is a significant observation that students who entered senior design with low motivation rose to the same level as other students.

**Project Selection**

Selection of the project is the crucial decision the student has to make by the end of design methodologies class offered in the junior year. The coding scheme enlightened some of the personal reasons, background influences and limitations/challenges the students faced in
making that choice. Students reported in the interviews that personal reasons for particular type of projects had influenced their decision in a major way. Personal reasons, family background, current goals, future goals, challenges/limitations were the major categories identified by the research teams under the theme of project selection. 20 different codes are identified under this theme and further segregated under suitable categories. Three most common codes under the personal reasons were, desire to design (code no 5), desire to help (code no 7), and industry projects (code no 4). These three codes clearly aligns with the three project choices offered in the senior capstone design course. Another category in the selection was the future goals. Company name, industry connections and potential job opportunity, all three codes under future goals clearly indicates that students were highly motivated to perform well in the project they opted for to sync with their future aspirations. However the interviews also highlighted the fact that some students could not be on a particular team because of security restriction of citizenships. They had to look for other project options which could align with their interest. Students also faced unfamiliar environments of the design course which was a challenge for them in the initial phase of senior capstone design course. The research team found these codes under project selection influential after through research on the data gathered from the exit interviews. These codes try to give an indication for the possible common attributes found in majority of senior capstone design students. Thus providing a framework for new coding scheme for future analysis.

**Project Process**

The project process theme highlights the essential period of the senior capstone design course. This includes the time from when they are assigned their respective projects in the beginning of the fall semester to the time of completion of the course in the end of spring semester. The phase is crucial as students experiences various motivational changes along their course journey. In the project process theme, researchers developed 37 codes. These codes were further divided into three categories, people, challenges/motivators and project requirement. In the exit interview students reported various resources on campus who
played a role of catalyst in their design project journey. Among the people category, students claimed to have received help from employee working in machine shop and student design center. However some teams also reported to have not received the same amount of help and guidance they were yearning for humanitarian resources were also reported to be limited. Some teams felt that certain delays in orders as well technical delays in the workshop hindered their design process and they could have used some more help with respect to such obstacles.

Among people, one important sub-category is the team. Students when asked about their team performance and how that played a role, stated mixed response. Individual skills, team dynamics and communication were highly common codes found in all the 9 teams’ data. Students mixed responses on this makes researchers draw attention towards the team chemistry and team size. From this study it shows that certain teams were highly motivated and their team had played a significant role in the higher motivation seen in the students. Team size was a major concern. Large teams like NASA JPL complained that their team size somewhere lead to their low performance in the senior capstone design course. Navy team also reported to have been benefited from a smaller team size. Smaller teams makes it beneficial for students as they feel more responsible for the amount of work that is divided in the team. Some teams also reported that pleasing their industry clients was a great motivators. It pushed them to perform better and present better in from of the industry project clients as they did not wish to let them down.

Another sub category which was frequently observed was the challenges/motivators. Some teams and students specified certain factors that either turned out as a motivator for them or as a challenge. Students reported to have been anxious during the whole senior capstone design course experience. Anxious was one of the highly observed code. It worked as an inhibitor for some and as motivator for rest. Anxiety is one of the most important factor in motivation. And observing this makes it a relevant point that students face anxiety at various stages of the course and it affects their motivation. Other important codes observed were confidence, time management, fear of failure, deadline pressure and motivation. All
these codes observed were frequent and common in both the industry teams and the non-industry teams.

Students mentioned that research oriented method for certain project types like the humanitarian projects inspired them to take a different approach which they had no previous experience with. Weekly presentations to the instructor and the respective industry clients also influenced the students working method, as they received regular feedback and guidance. On the same note, students also reported to have been disappointed about it as they felt they could have received better feedback. Thus the entire project process of the senior capstone design course walks us through different stages of student motivation and most importantly highlights the significant factors which could have played a vital role in their performance and individual motivation

**Project Results**

Project results has 12 codes divided under the skills, future and reflection categories. When asked about the future plans to students, half of the class expressed their desire to join industry and rest half desired to go to graduate school for higher education, engineering and MBA. Students also stated the skills they developed after this course and after their journey in earning a bachelor’s degree in mechanical engineering. They reported to feel confident as an engineer and also confident to enter industry. Senior capstone design course was listed to have played a great role as it was their first big design experience and some of the teams had the chance to work with an industry project, that made them feel ready to go into the work environment.

The most important section on the results was the reflection the students narrated from the experiences in the senior capstone design course. They stated how their learning quotient was changed and also that senior design course inspired them to go to graduate school. However some students also reported to have had potential success if they were on other teams. Some teams were not happy with their problem statement while some reported to have not liked the project they were involved in. Some students also stated that if given
another chance they would still select the same project and they were happy with the experience they got out of this. Thus the overall feedback received was mixed bag of experiences, emotions and success/failure stories. It is very interesting to get such findings in the research which may have not been discovered through a survey.

Thus the development of coding scheme for the senior capstone design course not only opened doors for more research but for the researchers on this team, who had performed quantitative analysis on the same cohort get a new perspective on the motivation and the factors affecting that motivation throughout the course. The scheme serves as the first step towards a larger goal. The use of this manual will be immense however for this study we aim at only discovering the significant factors, generation of possible themes and coding scheme and find the factors affecting the experiences and motivation in the senior capstone design students.

**Inter-rater Reliability:**

Cohen kappa reliability method was adopted to measure the reliability of the coding scheme developed. Cohen’s kappa statistic, k was measured by calculating the agreement between the two primary coders, where they compared the transcripts interpretation and classified the codes and themes from 9 interview data set. Kappa was calculated by calculating the frequency of agreement and the result was 0.99 which is almost perfect agreement. This indicates the developed coding scheme is reliable. This is the beginning of the path for more qualitative data analysis and codes.

It is important to note that while the Kappa value was very high, multiple iterations of the coding scheme were developed with corroboration with the same research team that performed the reliability analysis. Thus, it is expected that during the final scheme, the reliability was high as by then, the team came to agreement on how the scheme should be themed, subthemed, categorized and coded.
Addressing Proposed Research Questions

A summary of the research questions addressed is shown in Table 16. The table summarizes the findings used to address the research questions.

Table 16: Summary of Research Questions Findings

<table>
<thead>
<tr>
<th>ID</th>
<th>Research Question</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>Are there varying levels of student motivation between those who select industry sponsored versus non-industry projects?</td>
<td>The results shows there varying levels of motivation in students in two different project groups.</td>
</tr>
<tr>
<td>RQ2</td>
<td>Does the project type have a significance on the change of student motivation throughout the project duration?</td>
<td>Students start at different motivation levels but end the course with similar levels of motivation. Thus, project type does have impact on the motivation level of students who start with low motivation.</td>
</tr>
<tr>
<td>RQ3</td>
<td>Can a coding manual or scheme be developed specifically for Senior Capstone Design course application?</td>
<td>A generalized coding manual/scheme is generated specifically for senior capstone design course.</td>
</tr>
<tr>
<td>RQ4</td>
<td>Can qualitative data analysis using the aforementioned coding scheme provide insight on observations realized in the quantitative analysis?</td>
<td>The coding scheme provides significant codes highlighting the experiences of students during the course period. Further, themes are realized through the development of the scheme that reflect the student responses.</td>
</tr>
</tbody>
</table>
Chapter 6
Conclusion and Future Work

Students who are less or averagely motivated in the beginning of the senior capstone design course showed an increase in motivation by the end of the course which means that throughout their time in senior design, there have been factors that led to increase in motivation by the end of spring semester. From our research we aim to show that this could be related to their choice of project as our analysis indicates that industry teams showed an increase in motivation on completion of senior capstone design course. Students associated with industry teams begin the senior capstone design course with a low motivation but showed an increase by the end of spring semester indicating that their project choice may have contributed to the increase. Being associated with the industry client and working on their problem statements made them more confident in their ability as an engineer. Conversely non-industry team students had high motivation from the beginning of the Fall semester of the senior capstone design course and remained constant by the end of spring semester.

The researchers in this study also developed a coding scheme to better understand the motivation levels in student in senior capstone design course. The research team was able to find a deeper insights into the experiences and motivation levels of students at various stages throughout their journey in the course. The themes developed during the qualitative research analysis categorizes the codes generated by the coders. This theme lays a framework for the possible categories and code from exit interviews in future. This study aims to support future studies on motivation in students by providing the researchers with the significant factors that might affect motivation. The coding schemes aims it’s best to capture the missing parts of the student’s journey in the senior capstone design course.

With the goal of senior design capstone courses in mind, this research assists engineering educators determine which type of project offers should be available to students. As
anticipated, there are different gains achieved depending on the type of project students work on. As a result, educators must be considerate of the impact that project may have on the student and what may be best suited for their future.

This study aims at improving pedagogy by providing researchers and educators with an insight about students motivation based on their choice of project for senior capstone design course. To that aim, we conducted the mixed method study and provide with significant finding to improve the choice we offer to students in their design courses. Quantitative research done for this provides some significant results, however there is more scope for this research. Development of the coding scheme from the exit interviews is an iterative process. There will always be room for new codes and possible theme. This study aims at laying the foundation for future qualitative and quantitative research to be conducted in engineering education. The research team aims at using this coding scheme for a longitudinal motivation study for senior capstone design students. Thus I aim to go forward with this research and discover more.
References


23. Pintrich, P. *et al.* *A Manual for the Use of the Motivated Strategies for*


doi:10.18260/p.24775


57. Bochner, A. P. Unfurling Rigor: On Continuity and Change in Qualitative


Appendix A: MSLQ Survey

Name ______________________   Team: ______________

1. Florida Tech ID Number (e.g. 900XXXXXX):
   __________________________________

2. What is your academic standing?
   O Freshman
   O Sophomore
   O Junior
   O Senior

3. Were you a transfer student?   O Yes   O No

4. Are you a domestic or international student?   O Domestic   O International
   a. If international, state your country: __________________________
   b. If domestic, what is the Zip Code of your permanent home address (back home)? ______________

5. What is the highest degree earned by your parents? __________________________

6. What is your gender?  O Female   O Male  O Do not want to report

7. What is your age group?  O 17-20   O 21-24   O 25 and above  O Do not want to report

8. With which racial group(s) do you identify? (Mark ALL that apply)
   O African-American or Black
   O Caucasian or White
   O South Asian (e.g. Indian, Pakistani, Bangladeshi, etc.)
   O Other Asian
Rate the following items based on your behavior in this class. Your rating should be on a 7-point scale where

1= not at all true of me to 7=very true of me.

<table>
<thead>
<tr>
<th>Question</th>
<th>Not True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>(IV) I prefer work that is challenging so I can learn new things.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) Compared with other students in senior design I expect to do well</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(PA) I am so nervous during a presentation that I cannot remember facts I have learned</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) It is important for me to learn what is being taught in this class</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) I like what I am learning</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) I’m certain I can understand the ideas taught in this course</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) I think I will be able to use what I learn in this class in my life</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) I expect to do very well in this class</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) Compared with others in this class, I think I’m a good student</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) I often choose research topics I will learn something from even if they require more work</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) I am sure I can do an excellent job on the problems and tasks assigned</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(PA) I have an uneasy, upset feeling when I present</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) I think I will receive a good grade in this class</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) Even when I do poorly, I try to learn from my mistakes</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) I think that what I am learning in this class is useful for me to know</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) My study skills are excellent compared with others in this class</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(IV) I think that what we are learning in this class is interesting</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) Compared with other students in this class I think I know a great deal about the subject</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>(SE) I know that I will be able to learn the material for this class</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(PA) I worry a great deal about presentations</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(IV) Understanding the design process is important to me</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(PA) When I present I think about how poorly I am doing</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When I do homework, I try to remember what the teacher said in class so I can answer the questions correctly</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) I ask myself questions to make sure I know the material I have been studying</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) It is hard for me to decide what the main ideas are in what I read</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) When work is hard I either give up or study only the easy parts</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When I prepare for a presentation I put important ideas into my own words</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) I always try to understand what the teacher is saying even if it doesn’t make sense.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When I prepare for a presentation I try to remember as many facts as I can</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When preparing for a presentation, I copy my notes over to help me remember material</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) I practice presentations even when I don’t have to</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) Even when study materials are dull and uninteresting, I keep working until I finish</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When I prepare for a presentation, I practice saying the important facts over and over to myself</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) Before I begin studying I think about the things I will need to do to learn</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) I use what I have learned from previous classes to do prepare for project work</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) I often find that I have been reading for class but don’t know what it is all about.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) I find that when the teacher is talking I think of other things and don’t really listen to what is being said</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When I am studying a topic, I try to make everything fit together</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(SR) When I’m reading I stop once in a while and go over what I have read</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) When I read materials for this class, I say the words over and over to myself to help me remember</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(CV) I outline the relevant topics to help me prepare for a presentation</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
(SR) I work hard to get a good grade even when I don’t like a class

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>

(CV) When reading I try to connect the things I am reading about with what I already know.

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Appendix B : Exit Interview Questions

Exit Interview Questionnaire

1. Were you motivated to do well in this course? If so, what were you motivated by?

2. What factors enabled you to do well in this course?

3. Were there any factors that caused you to do poorly in this course?

4. Would you say you were anxious entering Freshman Design being your first exposure to design?

5. Were you anxious going into Senior Design?

6. Did you feel confident in your ability to engineer during Freshman Intro to Mechanical?

7. Did you feel confident in your ability to successfully complete your Senior Design project at the beginning of the year?
8. Do you feel more confident in your ability as an engineer having completed Senior Design?

9. For Senior Design, we have industry projects, competition projects, and open-ended humanitarian-based projects. What factors impacted your decision to choose an industry project?

10. If you could decide again today, would you still choose an industry project?

11. Were the factors that impacted your decision initially to choose industry project be the same factors that would impact it today to choose an industry project?

12. Do you feel you would have benefited more by joining a competition or humanitarian open-ended sponsored project?

13. Do you feel your performance would have been better had you joined a competition or humanitarian open-ended project?

14. Do you feel you would have learned more on a competition or humanitarian project?
15. Do you feel like you learned everything you expected to learn going into Senior Design?

16. Having completed this project, do you feel like you’re equipped to succeed on a competition or humanitarian project?

17. Do you believe the completion of this project better equips you to work on a competition or open-ended?

18. Do you wish to continue your education after graduation? If so, did Senior Design play any role in this?

19. Any final thoughts, information regarding Senior Design or anything in general?
Appendix C: IRB Documentation

Florida Institute of Technology
Institutional Review Board

Notice of Exempt Review Status:
Certificate of Clearance for Human Participants: Research

Principal Investigator: Besley Morris
Date: October 3, 2017
IRB Number: 17-148
Study Title: Engineering motivation and time allocation study

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.101, your study has been determined to have minimal risk for human subjects and exempt from 45 CFR 46 federal regulations. The Exempt determination is valid indefinitely. Subsequent changes to the approved exempt research must be requested and approved prior to their initiation. Investigators may request proposed changes by submitting a Revision Request form found on the IRB website.

Acceptance of this study is based on your agreement to abide by the policies and procedures of Florida Institute of Technology's Human Research Protection Program (http://webfit.fit.edu/irb/) and does not replace any other approvals that may be required.

All data, which may include signed consent form documents, must be retained in a secure location for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

The category for which exempt status has been determined for this protocol is as follows:

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement, survey procedures, interview procedures, or observations of public behavior) so long as confidentiality is maintained.
   a. Information is secured in such a manner that the subject cannot be identified, directly or through identifiers linked to the participant and/or
   b. Subject's responses, if known outside the research would not reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability, or reputation.
1. List the objectives of the proposed study.

The purpose of this study is to measure two student variables during their completion of their Senior Design Capstone course and determine if a correlation exists between such variables and their performance in the course. The two variables will investigate (1) what motivates individuals working in senior design capstone group projects to perform successfully and (2) measure how students allocate their time during senior design. The objective of this study is to determine if a correlation exists between motivation and time allocation to course success. Success is measured through both project advisor and customer (industry member or competition) evaluation of the project. The students chosen are part of the senior design program at the Florida Institute of Technology. The students will be working on their senior design projects which must be completed by the end of the Spring 2014 semester.

Ultimately, the goal of obtaining this information is to determine which incentives best motivate students to perform well in their senior design course and how to educate students on their allocation of time. This will be used for during subsequent capstone design courses at Florida Tech to maximize student project success.

2. Describe the research project design/methodology. Discuss how you will conduct your study, and what measurement instruments you are using. If your project will use a questionnaire or structured interview, attach. Please describe your study in enough detail so the IRB can identify what you are doing and why.

As this study will investigate two components of senior design, motivation and time allocation, two different studies will be administered:

Motivation Study
To measure student motivation, a survey will be administered to the students to collect data on varying forms of motivation. Two surveys are utilized here and attached to this form (Motivated Strategies for Learning Questionnaire and Motivational Dynamics Survey). This survey will be given to students during the beginning of the fall semester, beginning of the spring semester, and end of the spring semester. The goal is to perform a longitudinal study to identify changes within various types of motivation and identify how such changes could correlate to performance. Each survey instance is expected to take 20 minutes to complete. Performance is measured through course grades and industry feedback on project results. Alongside the final survey, interviews will be conducted with the students once they are grouped with other classmates to see what can be learned about team motivation versus individual motivation. Interviews will be performed with the team members and is expected to consume approximately 30 minutes per team. This will be used as a form of qualitative data in addition to the quantitative data collected from the survey.

Time Allocation Study
To measure time allocation, students will submit a form on a weekly basis which identifies their time allocation. This form is attached (Time Allocation Study). This study will require students perform an interview during the end of the fall and spring semester. This interview will be coupled with the interview required for the motivation study. The interview will inquire on how the team distributed their time, their reflection on their distribution, and what they would do differently.

3. Describe the characteristics of the subject population, including number, age, sex, and recruitment strategy (attach actual recruitment email text, recruitment flyers etc).

Study five (55) students from the Mechanical Engineering Design course will be surveyed in this study. No recruitment notification will be solicited as all students are part of the course and will be verbally recruited to participate in the study. Students consist of senior undergraduates students majoring in Mechanical Engineering. The age and sex of the students vary throughout the sample size.

4. Describe any potential risks to the subjects (physical, psychological, social, legal, etc.) and assess their likelihood and seriousness. Research involving children must carefully assess risks and describe the safeguards in place to minimize these risks.

There exist no potential risks in this study.
5. Describe the procedures you will use to maintain the confidentiality and privacy of your research subjects and project data.

Students will be assigned an alphanumeric identification tag which is coded to contain their group project and team association (i.e., ProjTeam234). The identification tag will not possess the student's name or any part of their full name. This document will be viewed by Dr. Monica only and will be destroyed after the study. This identification tag will be used to determine the project and team association of each student.

6. Describe your plan for informed consent (attach proposed form).

A consent form (attached) will be given to the students before administering the survey. Students may opt to not participate in this study at no consequence.

7. Discuss the importance of the knowledge that will result from your study and what benefits will accrue to your subjects (if any).

The importance of this study lies in understanding the impact of motivation and time allocation in senior design projects. This knowledge may assist faculty in understanding how to train students on time allocation and deploying the most successful motivation methods to ensure project completion. Subjects may learn from their reflection on the course during the final survey and interviews. This will allow students to recount their journey from their experiences and inform them for future projects.

8. Explain how your proposed study meets criteria for exemption from Institutional Review Board review (as outlined on page 1 of this form).

This research meets the criteria for exemption as it meets criterion 1 by performing the research in an educational setting (classroom) and involving normal educational practices. The educational practice will be used to compare the effectiveness of various time allocation methods (team management) and various forms of motivation (goals, prizes, instructor satisfaction, or industry satisfaction). This study falls under the first exemption of the IRB review.
Signature Assurances

I understand Florida Institute of Technology's policy concerning research involving human subjects and I agree:

1. to accept responsibility for the scientific and ethical conduct of this research study,
2. to obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form,
3. to immediately report to the IRB any serious adverse reactions and/or unanticipated effects on subjects which may occur as a result of this study,
4. to complete, on request by the IRB, a Continuation Review Form if the study exceeds its estimated duration.

PI Signature ___________________________________________ Date____________________

Advisor Assurance: If primary investigator is a student

This is to certify that I have reviewed the research protocol and that I attest to the scientific merit of the study, the necessity for the use of human subjects in the study to the student's academic program, and the competency of the student to conduct the project.

Major Advisor ___________________________________________ Date____________________

Major Advisor (print) ________________________________

Academic Unit Head: It is the PI's responsibility to obtain this signature

This is to certify that I have reviewed the research protocol and that I attest to the scientific merit of the study and the competency of the investigator(s) to conduct the study.

Academic Unit Head ______________________________________ Date____________________

FOR IRB USE ONLY

IRB Approval ___________________________________________ Date____________________

Name ___________________________________________

IRB #

Florida Tech IRB: November 2005
Engineering Capstone Design Motivation and Time Allocation Study

Description of the Study and Your Part in It

You are invited to participate in a research study conducted by Dr. Benjy Markos and Amanda Benette. Dr. Markos is an assistant professor within the Department of Mechanical and Aerospace Engineering at the Florida Institute of Technology. Amanda Benette is a graduate student at the Florida Institute of Technology, running this study with the assistance of Dr. Markos. The purpose of this research is to determine what motivational factors best promote designers to generate innovative solutions and how time is allocated throughout the design process.

Your part in the study will be to provide your opinion about different incentives and how they potentially motivate you to be innovative when designing.

The follow up surveys will be conducted with you and your Senior Capstone Design group mates; this will be done to reduce the amount of time necessary for these interviews and to see if the motivation on the team level is different than the individual level.

The total amount of time required for your participation will be about 45 minutes over 3 sessions (15 minute survey and 30 minute interview). Sessions will be held during the beginning of the Fall and Spring semester and the end of the Spring semester.

Risks and Discomforts

We do not know of any risks or discomforts to you in this research study.

Possible Benefits

While there may be no immediate benefits, this study will assist you in reflecting on the motivational factors contributing to your success. This research may help us to understand how to incentivize engineers to be innovative.

Incentives

None.

Protection of Privacy and Confidentiality

Your confidentiality will be maintained by coding your information and responses with an alphanumeric identification tag. The same code will be assigned to you on all days of the experiment. A coding sheet will be kept during the experiment to ensure the data is processed accurately.

Amanda Benette
abbette2090@my.fit.edu
consistently. After completion of the study, this data will be destroyed. Further, we will only collect data regarding your opinion towards different incentives; data will NOT be collected regarding personal information. We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study.

Choosing to Be in the Study

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study.

If you decide not to take part or to stop taking part in this study, it will not affect your grade in any way.

Contact Information

If you have any questions or concerns about this study, or if any problems arise, please contact Amanda Bessette (abessette2009@fit.edu) or Dr. Bednok-Morhous (bemorhous@fit.edu).

If you have any questions or concerns about your rights in this research study, please contact the Florida Institute of Technology Office of Research at (321) 674-8000 or Dr. Steelman at steelma@fit.edu. A copy of this form will be given to you.
Appendix E: Original Coding Scheme Draft