Examining the Differences in Student Motivation for Industry Projects and Non-Industry Projects in Senior Capstone Design

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Abstract

This paper 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 Florida Institute of Technology fall into one of two major project types: industry sponsored and non-industry sponsored. Industry-sponsored projects are provided through industry partnerships and include government funded and privately funded. Non-industry projects at the university include competition based projects, such as SAE Formula and SAE Baja; and humanitarian based projects. 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 t-test for single variance to examine which factors affected student motivation.

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, this research aims to revolutionize 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.

The results indicate that students working on industry-sponsored design projects exhibit increased motivation throughout the course of the year versus their non-industry counterparts. However, the non-industry project groups typically had higher motivation levels entering into the senior capstone design experience than the industry-sponsored project teams.

Keywords:

Senior Capstone Design, Motivation, Project Type, Industry Projects, University Projects

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 senior capstone design course are offered various project choices, from two major categories: industry sponsored and non-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 on real world industry projects. However, there is still a lot of information to be gathered to determine 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 university/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.

Senior capstone design has become a centerpiece of student experiential learning within the curriculum. Further, it has afforded engineering educators an opportunity to experience how students learn in nontraditional modes (compared to the in the classroom counterpart). Senior 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.[1] In an effort to understand the impact of senior design, we aim to understand how a particular project type impacts students. Understanding how project types contribute to students' motivation in senior design affords the ability to improve the educational process of the course through 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.

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 and studied longitudinally. The cohorts belong to three different academic senior design years: 2013-2014, 2014-2015 and 2016-2017. Data is collected utilizing the Motivated Strategies for Learning Questionnaire (MSLQ) at the beginning of the fall semester when they are introduced to their project (two weeks into the course) and at the end of the senior design course, approximately two weeks before the end of the academic year.[2] This data is compared against the type of project students selected: industry sponsored versus non-industry. The objective of this research is to address two research questions:

RQ1: Are there varying levels of student motivation between those who select industry sponsored versus non-industry sponsored projects?
Hypothesis: The researchers hypothesize that there are varying levels of motivation observed between students who select one type of project compared to their counterpart

RQ2: Does the project type have a significance on the change of student motivation throughout the project duration?
Hypothesis: The researchers hypothesize no differences are observed in changes to student motivation between industry sponsored and non-industry projects

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.

2.1. Senior Design

Senior capstone design is one bridge that connects students to professional engineering industry. Senior capstone design is a 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 through redesign or innovation. Design is an integral part of mechanical engineering. Students at the Florida Institute of Technology often claim to have entered mechanical engineering solely for their curiosity and passion to design something new.[3] Senior capstone design is also unique because students get to work as a team, thus giving them a preview of the industry where employees work in a team based environment. Competition projects are the best choice when it comes to re-designing an existing model and improving its previous performance. Humanitarian projects intend to help people in the lesser developed countries by providing solutions to the struggles they face for basic facilities like shelter, food, and water. They aim at providing cost effective products that are affordable to people all around the world. Humanitarian projects also provide the liberty to students to establish their own problem statement. It doesn't necessarily have to be from the university or the course instructor. In such cases, students provide instructors with their top three project statements and areas they wish work in, the instructor then finalizes one of them after analyzing all the requirements and project path. The emergence of this course comes from various sources like the Accreditation Board for Engineering and Technology, Inc. (ABET), local industries, and individual school requirements.[4]

Further, senior design provides students the opportunity to work on a project where they can both address both technical requirements (something they learn in course work) and learn how to manage projects (an aspect of engineering they have yet to learn).[5] Prior research performed by the authors has determined that motivation plays a significant role on students' performance in senior design capstone courses.[3,6–8] As such, we implement qualitative research methods to assist in explaining this phenomenon.

2.1.1. Senior Design at Florida Institute of Technology

At Florida Institute of Technology, senior capstone design course spans across three semesters: second semester of junior year, first semester of senior year, and second semester of senior year. The first course of the sequence, 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 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 for the senior capstone design course. They are provided with the list of industry, competition, and university project topics. Students typically select projects based on personal interest and career goals. In all cases, students are assigned to a project (or team mate) that was listed in one of their three choices. Most of the students are assigned to their first choice of project or teammate.

During the two senior design courses, students work on 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 (PDR). During the second semester, teams fabricate their design, perform testing, and iterate as needed before submitting their critical design review (CDR) at the culmination of the project.

2.2. Student Motivation

This paper considers motivation as the lens for which we will perform the study. Motivation is considered here as a student's natural inclination to select a specific type of project versus another – an inclination we believe is rooted in motivation. Often, students select projects 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 SAE 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 their future career decisions.[9,10] To measure motivation, we utilize the MSLQ.[11,12] The MSLQ is a robust survey that has been used in various types of learning contexts outside of engineering such as medicine.[11] 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 me" and "very true to me". This questionnaire is designed to measure motivation through five individual factors: cognition value, intrinsic value, self-regulation, presentation anxiety, and self-efficacy. According to Pintrich.[11,12] these five factors are some of the important factors in identifying student motivation. 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.[13]

This research is built on the foundation of the 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 students possess a different type of motivation?

The authors hypothesize that a factor that could contribute to motivation are the type of projects students are assigned. Specifically, the authors aim to determine whether industry based projects, where an immediate customer (external to the school) exists, influence the students' motivation levels throughout the course of senior capstone design.

Cognition is defined as a student's ability to conceive information and to process it though individual capability.[14] It also includes processes like analyzing and problem solving,[14] which industry has particularly identified while hiring engineers. There have been instances when students feel lack of self-judgment and problem solving ability when they are hired due to little or no exposure to industry/real world problems. There is a continuous effort from both the educators and engineering industry to lessen this gap and prepare the students to face the real-world industry environment. This is one inspiration for incorporating industry sponsored projects in senior capstone design as it gives students an opportunity to get a close view of the working environment and methods they need to adapt to before entering industry.

Intrinsic value is the inclination of a student's participation in activities that involve individual curiosity or enjoyment of the activity.[11,15] Student's often tend to lose interest if they face unfamiliar coursework, making senior design an interesting course to measure intrinsic value. This could be applicable in the case where students join a competition project despite their inclination toward industry projects or humanitarian projects. This not only results in the student losing interest in terms of course work, but also affects their motivation level by going through mandatory and unexciting project responsibilities. Thus making the student feel out of place and disinterested.[3]

Self-regulation is the student's ability to organize oneself in terms of necessary of course work or assigned responsibilities.[3,11] Self-regulation not only affects individual motivation, but for a team project like capstone design, it also contributes to team dynamics and overall performance of the team. This is different from cognitive value as it focuses on the structured method to achieve the team's goal.[3]

Test anxiety is the anxiousness experienced by an individual while appearing for a test,[11] which is altered for the purpose of this study to focus on presentations. Industry sponsored project teams have a more rigorous presentation schedules in comparison to the non-industry project teams at Florida Institute of Technology. This is because the industry sponsored projects are funded by the private or government companies, therefore they are presenting to the client 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.

Self-efficacy is an essential component of cognition theory.[16] Self-efficacy is defined as one's ability to complete a task by taking necessary actions towards that goal.[16,17] Self-efficacy have shown signs of connection between student's performance and persistence.[18] Self-efficacy is further described as an amalgamation of these four traits which ultimately lead to completion of a task or a goal:[17]

1. Previous performance experiences or achievements
2. Past experiences of enjoying the participation or work
3. Peer/societal persuasions towards something
4. Physiological scenarios

These four traits adds up to define a student's self-efficacy. The term self-efficacy was introduced in the year of 1997.[13] Various non-engineering fields have reported to use self-efficacy for analyzing social skills, behavior, and more.[19]

Our study measures the above described five factors through the MSLQ questionnaire to identify student's motivation levels at the beginning and end of the senior capstone design course. These factors are affected by the student's experiences with their work or their gradual outlook towards a task/goal. Thus, this research aims to examine whether the student's project choice affects their motivation factors.

2.3. Industry Projects

Industry sponsored projects have problem statements that are provided by the company, which is typically a problem they are currently addressing or wish to in the future. The problem statement is provided to the team when entering senior capstone 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. In some instances, students have to develop their own requirements through various methods.[20,21] The goal of industry sponsored teams 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 for the team, an industry representative attends their weekly presentations and provides feedback to the teams and the faculty. 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 the workforce. Various industry sponsored projects offered include, but are not limited to: NASA JPL, U.S. Navy, Lockheed Martin, Harris Corporations, Google, Northrop Grumman, and United Launch Alliance. An example industry sponsored project problem statement is shown below:

Sponsor: NASA JPL

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.

Research has shown that first-hand experience on an industry sponsored project helps create a foundation for future industry needs.[22] For example, a senior capstone design course developed at Brigham Young University focused solely on the industrial design and manufacturing. The school found that student were excited to see their ideas transform into reality through the use of manufacturing.[22] Similar to industry projects, industry sponsored projects tend to be multidisciplinary in terms of team make up and project requirements.

2.4. Non Industry Projects

Non-industry projects are 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 (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:

Engineering Design	150
Cost & Manufacturing Analysis	100
Presentation	75
Acceleration	75
Skidpad	50
Autocross	150
Fuel Economy	100
Endurance	300
Total Points	1,000

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.

Humanitarian projects are intended to address students who have altruistic engineering thrusts. 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 humanitarian teams begin developing their problem statements toward the end of their junior design course, directly after they are assigned their project team. Their advisory committee, comprised of the course professor, graduate students assistants, and university representatives, assist the students with making a project choice that is within the scope of senior design. This includes developing their problem statement and determining the deliverables, time, and budget constraints of the project. Humanitarian projects range in scope from design and development of a system (including relevant background research, calculations, and formulation of a design) to a complete design and construction of a working system.

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.

2.5. Project Evaluation

Though projects may be different in thrust and goals, all projects are required to follow a systematic process that is graded as such. The teams follow a systematic design process whereby they develop requirements, generate concepts, perform concept analysis/justification, perform experiments/testing, and recommend a final solution. Two formal deliverables are expected in the form of a Preliminary Design Review (PDR) and Critical Design Review (CDR) at the end of the fall and spring semester, respectively. The deliverables are uniform throughout the course to ensure each students learns how to implement the formal systematic design process. It is expected and anticipated that each team will exhaust varying times on each of the various steps however. For instance, the humanitarian teams will exhaust more time on requirements elicitation as they have to generate their own set of requirements from scratch.

3. Research Method

This research was performed through the use of three cohorts of senior capstone design students. Each cohort participated in the research where they self-evaluated their motivation level through the MSLQ survey. Case studies are a popular experiment type in both academic and corporate settings.[22],[23] 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.

3.1. Survey 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 the MSLQ survey which consisted of 43 questions to self-report 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 student's motivation was studied at two instances in time: the beginning of the fall semester and at the end of the spring semester of senior capstone design. Table 1 shows number of questions related to each factor defining overall motivation.

Table 1*: Motivation factors in MSLQ survey*

Motivation Factors	Number of Questions
Cognitive Value	12
Self-regulation	9
Intrinsic Value	9
Self-efficacy	9
Presentation Anxiety	4

3.2. Study Subjects

The instrument was administered to a total of 188 senior design students studying mechanical engineering over the three year cohort period (2013-14, 2014-15, and 2016-17). All students in the course were seniors enrolled in mechanical engineering with an expected graduation at the end of the year. Table 2 details the project and gender data of the subjects.

Table 2*: Subjects Gender and Project Selection Information*

	Industry Sponsored	Non-Industry		**Total**
		Competition	Humanitarian	
Male	55	92	23	170
Female	7	8	3	18
Total	62	100	26	188

3.3. Data Collection

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. Minor changes were made to the questions to put them in the context of senior design. For instance, since senior design does not include tests or examinations, questions relating to test anxiety were converted to presentation anxiety. Questions were not significantly changed and terms that were applicable to senior design were incorporated. The adapted version of the MSLQ used in this study is shown in the appendix. Since the core purpose of the questions were not changed, the instrument did not need to be revalidated through a confirmatory factor analysis.

The questions in the survey aim at addressing the five factors contributing to the overall motivation of an individual. The questions addressing each of the five factors are shown in the MSLQ survey in the appendix. 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 aim at determining the average value for each of the five factors.

3.4. 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 questions 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.

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 t-test may be performed.

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.

4.1. ANOVA Single Factor analysis

The five factors contributing to student's motivation were analyzed using ANOVA and t-tests where appropriate. The ANOVA analysis assisted in determining where differences between responses were observed.

Results obtained from the statistical analysis reveal 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 students in competition and university project types. Table 3 shows the results obtained from the fall semester data with respect to 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 3: Fall and Delta Cognitive Values

Teams (Cognitive Value)	**Fall** $\bar{x} \pm \sigma$	**Delta** $\bar{x} \pm \sigma$
Competition	5.24±0.67	-0.01±0.97
Industry	4.96±0.72	0.19±0.89
Humanitarian	5.35±0.62	-0.29±0.95
p-value	0.013	0.087

As shown in Table 4, the analysis revealed that competition teams had higher intrinsic value in the spring semester. Industry and competition teams did not have a significant difference in their average values. While industry teams showed a notable increase when compared to the delta value with other teams, it was not this way for competition and university teams. No differences were observed between teams for intrinsic motivation in the fall semester.

Table 4: Spring and Delta Intrinsic Motivation Value

Teams (Intrinsic Motivation)	Spring $\bar{x} \pm \sigma$	Delta $\bar{x} \pm \sigma$
Competition	6.24±0.61	0.57 ± 0.88
Industry	5.98±0.69	0.32 ± 0.69
Humanitarian	5.85±0.84	0.25 ± 0.54
p-value	0.009	0.058

As shown in Table 5, self-efficacy is higher in competition teams in the spring semester. Industry teams were the median value for self-efficacy in the spring semester compared to the rest of the teams. The delta value for the industry teams was again the median in comparison 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 5: Spring and Delta Self Efficacy Values

Teams (Self-Efficacy)	Spring $\bar{x} \pm \sigma$	Delta $\bar{x} \pm \sigma$
Competition	6.17±0.62	0.73±0.90
Industry	5.92±0.67	0.51±0.80
Humanitarian	5.58±0.84	0.32±0.66
p-value	0.0002	0.048

As shown in Table 6, 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 the senior capstone design course. No differences were observed between teams for self-regulation in the spring semester and deltas between fall and spring.

Table 6: Self-Regulation Vales during Fall Semester

Teams (Self-Regulation)	Fall $\bar{x} \pm \sigma$
Competition	5.20±0.83
Industry	4.80±0.85
Humanitarian	5.05±0.69
p-value	0.013

As shown in Table 7, the presentation anxiety was 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 7: Presentation Anxiety

Teams (Test-Anxiety)	Fall $\bar{x} \pm \sigma$
Competition	4.33 ± 1.70
Industry	3.76±1.64
Humanitarian	4.55±1.48
p-value	0.048

A summary of the results is shown in Table 8. The table highlights the statistically significant findings revealed through the ANOVA analysis.

Table 8: Statistically Significant Results of ANOVA Analysis

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

4.2. Mean Comparison Results

To further analyze the ANOVA results, a t-test is performed to compare project types for fall, spring, and deltas in motivational factors. The factors in the Table 9 are 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 9: Means and Standard Deviations of Statistically Significant Factors

Factors	Industry Teams $\bar{x} \pm \sigma$	Non – Industry Teams $\bar{x} \pm \sigma$	p-value
Fall-cognition	4.96±0.72	5.30±0.65	0.004
Fall-self-regulation	4.80±1.64	5.12±0.76	0.005
Fall-anxiety	3.76±1.64	4.46±1.60	0.017
Delta-cognition	0.19±0.89	-0.15±0.96	0.079
Delta-self-regulation	0.09±1.00	0.39±0.97	0.061

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.

5.1. 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. However 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. To achieve similar cognitive gains, some of the attributes of industry projects should be implemented within non-industry projects. For instance, consider the continually changing requirements that industry projects have to deal with, often coined the "moving target" effect. Educators should consider implementing such attributes as students may grow from the challenging experience.

For the intrinsic factor, results show that the competition teams had a higher intrinsic value (6.24±0.61) compared to the industry and university teams in the spring semester. The delta intrinsic value shows that industry teams increased to the median value indicating that the intrinsic value increases across the two 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. This may have been due to the project type that they are involved with; industry projects allow students to experience real-world prompts, therefore improving their confidence as an engineer over the course of senior capstone design. This could also be impacted by feedback from their industry representatives. Intrinsic motivation has been shown to be impacted by extrinsic motivation.[24] Therefore, positive feedback from their industry client regarding their deliverable at the end of the course can increase the student's intrinsic value.

Self-efficacy is the conscious awareness of successfully completing any task based on an individual's ability.[17] The analysis of self-efficacy among the senior students showed that industry teams were the median group for self-efficacy in the spring semester. The delta value for self-efficacy also was the middle value, with the industry teams experiencing an increase in self-efficacy. This indicates that the students on industry teams experienced an increase in confidence throughout the course of senior capstone design. This could be due to the fact that industry projects are one way of providing the student with real world projects, thus creating a connection between the coursework and its applications.

When asked to evaluate themselves on the MSLQ survey, our analysis showed 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 contributed to the fact that competition team students have previously involved themselves on the team during their junior design or in SAE clubs. This makes these students more aware of the tasks they need to do or the path to follow. Industry teams, on the other hand, face the completely new environment of the real-world industry problems, decreasing their self-regulation.

Presentation anxiety refers to the nervousness a student encounters during presentations. 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. Soft skills play an equal role in the success of an engineer to the technical skill sets. Industry teams get an extra layer of exposure to overcome presentation anxiety and thus we hypothesize that it does plays a significant role in the overall motivation of the senior capstone design students.

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 the completion of the course and competition teams had the highest intrinsic motivation by the end of the academic year. Industry teams increased cognition, self-efficacy and intrinsic motivation in comparison to competition and university teams by the end of the spring semester. Thus it can be stated that involvement with an industry project helped students to gain confidence and increased their motivation as they felt a connection to the industry environment and better equipped to face such a challenge in future. As educators we can incorporate certain attributes from the findings in the way we cater the senior design projects to students.

5.2. 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 cognitive value 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.

5.3. Study Limitations

It’s important to note that while the motivation level of students is measured against various types of projects, we do not consider the effects this has on student performance on the project. While such a study is necessary, it is outside the scope of this particular paper and will be studied in subsequent papers. Thus, this paper focuses on determining if there are differences between student motivation in project selection, which is a necessary question that must be addressed before determining its effect on their performance in the course.

6. Conclusion

Students with low or average motivation in the beginning of the senior capstone design course showed an increase in motivation by the end of the course. This indicates that there are factors that exist in senior capstone design that increase the student's motivation throughout the course. This study finds that some of those factors may be related to the student's choice of project, as our analysis indicates that industry teams showed an increase in motivation by the completion of the senior capstone design course. Students associated with industry teams begin the senior capstone design course with low motivation, but showed an increase by the end of spring semester. Weekly association with their industry client and receiving positive feedback regarding their designs and ideas made them more confident in their ability as an engineer. Conversely, non-industry team students had high motivation at the beginning of the fall semester of senior capstone design, which remained consistent by the end of spring semester.

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 that 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.

7. References

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8. Appendix:

Motivated Strategies for Learning Questionnaire

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
   O East Asian (e.g. Chinese, Korean, Japanese, etc.) O Native Hawaiian or Pacific Islander
   O American Indian or Alaskan Native O Other_________________________
   O Do not want to report

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**.

Question	Not True						Very True
(IV) I prefer work that is challenging so I can learn new things.	1	2	3	4	5	6	7
(SE) Compared with other students in senior design I expect to do well	1	2	3	4	5	6	7
(PA) I am so nervous during a presentation that I cannot remember facts I have learned	1	2	3	4	5	6	7
(IV) It is important for me to learn what is being taught in this class	1	2	3	4	5	6	7
(IV) I like what I am learning	1	2	3	4	5	6	7
(SE) I'm certain I can understand the ideas taught in this course	1	2	3	4	5	6	7
(IV) I think I will be able to use what I learn in this class in my life	1	2	3	4	5	6	7
(SE) I expect to do very well in this class	1	2	3	4	5	6	7
(SE) Compared with others in this class, I think I'm a good student	1	2	3	4	5	6	7
(IV) I often choose research topics I will learn something from even if they require more work	1	2	3	4	5	6	7
(SE) I am sure I can do an excellent job on the problems and tasks assigned	1	2	3	4	5	6	7
(PA) I have an uneasy, upset feeling when I present	1	2	3	4	5	6	7
(SE) I think I will receive a good grade in this class	1	2	3	4	5	6	7
(IV) Even when I do poorly, I try to learn from my mistakes	1	2	3	4	5	6	7
(IV) I think that what I am learning in this class is useful for me to know	1	2	3	4	5	6	7
(SE) My study skills are excellent compared with others in this class	1	2	3	4	5	6	7
(IV) I think that what we are learning in this class is interesting	1	2	3	4	5	6	7
(SE) Compared with other students in this class I think I know a great deal about the subject	1	2	3	4	5	6	7
(SE) I know that I will be able to learn the material for this class	1	2	3	4	5	6	7
(PA) I worry a great deal about presentations	1	2	3	4	5	6	7
(IV) Understanding the design process is important to me	1	2	3	4	5	6	7
(PA) When I present I think about how poorly I am doing	1	2	3	4	5	6	7
(CV) When I do homework, I try to remember what the teacher said in class so I can answer the questions correctly	1	2	3	4	5	6	7
(SR) I ask myself questions to make sure I know the material I have been studying	1	2	3	4	5	6	7
(CV) It is hard for me to decide what the main ideas are in what I read	1	2	3	4	5	6	7
(SR) When work is hard I either give up or study only the easy parts	1	2	3	4	5	6	7
(CV) When I prepare for a presentation I put important ideas into my own words	1	2	3	4	5	6	7

(CV) I always try to understand what the teacher is saying even if it doesn't make sense.	1	2	3	4	5	6	7
(CV) When I prepare for a presentation I try to remember as many facts as I can	1	2	3	4	5	6	7
(CV) When preparing for a presentation, I copy my notes over to help me remember material	1	2	3	4	5	6	7
(SR) I practice presentations even when I don't have to	1	2	3	4	5	6	7
(SR) Even when study materials are dull and uninteresting, I keep working until I finish	1	2	3	4	5	6	7
(CV) When I prepare for a presentation, I practice saying the important facts over and over to myself	1	2	3	4	5	6	7
(SR) Before I begin studying I think about the things I will need to do to learn	1	2	3	4	5	6	7
(CV) I use what I have learned from previous classes to do prepare for project work	1	2	3	4	5	6	7
(SR) I often find that I have been reading for class but don't know what it is all about.	1	2	3	4	5	6	7
(SR) I find that when the teacher is talking I think of other things and don't really listen to what is being said	1	2	3	4	5	6	7
(CV) When I am studying a topic, I try to make everything fit together	1	2	3	4	5	6	7
(SR) When I'm reading I stop once in a while and go over what I have read	1	2	3	4	5	6	7
(CV) When I read materials for this class, I say the words over and over to myself to help me remember	1	2	3	4	5	6	7
(CV) I outline the relevant topics to help me prepare for a presentation	1	2	3	4	5	6	7
(SR) I work hard to get a good grade even when I don't like a class	1	2	3	4	5	6	7
(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