A Mixed Methods Analysis of Motivation Factors in Senior Capstone Design Courses

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Abstract

This paper presents a continuation of prior research exploring the impact of motivation factors on performance in cornerstone and capstone design courses. The previous longitudinal study focused on a single cohort of 32 students, examining their motivation at two instances in time: their freshman cornerstone design course and their senior capstone design course. The results from the prior quantitative research revealed that student grades in their freshman cornerstone design course were impacted by their anxiety levels with significance. The student's senior capstone design grades were determined by their intrinsic motivation, and the delta in their grade between their freshman and senior year was correlated to their freshman year anxiety and their residency.

An interesting finding from the quantitative survey was the student's anxiety levels did not decrease significantly between their cornerstone and capstone design course. However, the student's capstone design grades were not affected by their anxiety. This indicated that there was a paradigm shift in which the students no longer allowed their anxiety to dictate their performance in design courses. This prompted the authors to further explore the impact of motivation on the student's performance in their senior capstone design courses. This study focuses on a cohort of 80 students, and uses data from two instances in time: their Fall and Spring senior capstone design course. The findings from the prior longitudinal study also impelled the authors to implement a qualitative survey to gain insight into the student's perspective of their motivation. Both of the surveys measure five factors of student motivation: cognitive value, intrinsic value, self-regulation, self-efficacy, and test/presentation anxiety.

This paper presents quantitative and qualitative results to further explore the impact of student motivation on their performance in senior capstone design courses. The study also examines the student's motivation factors with regard to their demographic information. This includes the student's gender, age, residency (domestic or international), family income, and the highest degree attained by parents.

The results of the study indicate that the students' fall, spring, and change in performance are all impacted by their intrinsic value, with the students' spring performance being further exacerbated by their cognitive value. Their performance in the spring is also found to be closely related to their residency. Interestingly, the student's intrinsic value actually dropped, with significance, between the beginning of the fall and end of the spring semester. The results of the qualitative study indicate that the students who were confident entering into senior capstone design identify necessary areas of improvement by the end of the two semester course.

Keywords: Student Motivation, Freshman Cornerstone Design, Senior Capstone Design, Engineering Education, Engineering Retention

1. Introduction

Engineering curriculum at the university level typically culminates in a senior design capstone course. The goal of the senior capstone design course is to challenge the students with an example of a real-world project, preparing them for industry. University curriculum used to focus heavily on design and design challenges, typical of industry level engineering. Due to increasing system complexity, engineering curriculums were prompted to add more science and mathematics classes to help students understand needed tools and methods.[1] However, over time this produced students with a decreasing understanding of the practical applications of engineering and design.[1] The reintroduction of modern day senior capstone design in the 1980's and 1990's served to bring the practical application of technical topics back to university level engineering.[2,3] It was recently identified that corporations also yearned for students entering industry to have a greater understanding of problem solving, critical thinking, and presentation and communication skills.[4] Senior capstone design serves as a transition from compartmentalized learning experienced in introductory level engineering courses to the design and application desired by students entering industry. Further, it provides students the opportunity to work on a project where they can both address both technical requirements and learn how to manage projects.[5] Prior research performed by the authors has determined that motivation plays a significant role on students' performance in senior design capstone courses.[6–9] As such, we implement qualitative research methods to assist in explaining this phenomenon.

Many studies have observed motivation as a predictor of academic performance.[10–12] Busato, et. al, identified that motivation and intellectual ability were the two key indicators of academic success at the university level.[12] Pintrich implemented the Motivated Strategies for Learning Questionnaire (MSLQ) to measure student motivation levels and hypothesized their importance for academic performance. Intrinsic motivation factors have been closely linked to design thinking and creativity in designing.[13] It is hypothesized that motivation factors impact student performance in design courses and ultimately their success in senior capstone design.

A previous longitudinal study conducted by the authors examined the impact of student motivation on performance in cornerstone and capstone design courses for the common group of 32 students that had maintained the proper, four-year trajectory between freshman and senior year. One interesting finding was that the students' anxiety levels did not change between their first and last years of undergraduate curriculum, however the senior capstone design students mitigate their anxiety using their cognitive value. This prompted the authors to further explore the motivation levels the senior capstone design students, including the implementation of a qualitative exit interview to examine key factors that the students identified.

The goal of this study is to explore the impact of student motivation on academic performance in senior capstone design courses. The study also observes these variables with respect to the student's demographic information, including their gender, age, residency (domestic or international student), family socialization, (including parents' highest levels of education and household income) and academic history– through the use of student cumulative grade point average (GPA) and whether or not the student had transferred into the university.

This research specifically addresses three research questions (RQ):

> ***RQ1: Does a correlation exist between motivational factors and student success during each individual semester of Senior Capstone Design (fall and spring)?***
>
> ***RQ2: Does a correlation exist between motivational factors and the change in student success over the course of the two semester senior capstone design course?***
>
> ***RQ3: Can qualitative data collected via a team interview format provide insight into specific variables impacting student motivation and performance in senior capstone design?***

2. Background

This study utilizes qualitative data to gain insight on the results of a quantitative analysis of motivation levels and their impact on performance in senior capstone design. The quantitative study makes use of a modified version of Pintrich's MSLQ to measure five motivation factors: cognitive value, intrinsic value, self-regulation, self-efficacy, and presentation anxiety. The performance metric in the study is measured using the student's final grade in the course. Both the student's motivation and performance are also viewed with respect to the student's demographic information, including their gender, age, residency, family socialization, and academic history.

2.1. Senior Capstone Design Courses

Senior capstone design has been regarded as the pinnacle of an undergraduate's engineering education. While the essence of senior capstone design has been dated back to the late 18th and early 19th centuries, these courses began to resurface in the 1970's. However, their significance in the curriculum went unrecognized, with approximately 3% of American institutions offering a formalized design curriculum.[14] Modern day capstone courses did not emerge until the early 1990's.[3] Senior capstone design serves to prepare students for industry by bringing practical application of design back to the university level.[2] It is typically the student's first exposure to team- and project- based engineering similar to what they will experience as a professional engineer. Its importance has been emphasized by accreditation bureaus such as the Accreditation Board for Engineering and Technology, Inc. (ABET).[2,15]

At Florida Institute of Technology, senior capstone design is a final requirement before graduation from undergraduate engineering curriculum. The course is a three semester sequence, preparing students for industry. The first course, Design Methodologies, takes place during the student's spring semester of their junior year. This course is intended to equip the students with all of the skills and considerations necessary to complete their senior capstone design projects. The course overviews the basics of the design process, the preparation of technical reports and presentations, and different problem-solving methodologies.[16] The students are assigned three mini group projects to introduce them to project-based course requirements and allow them to employ the skills they are learning at the time. Design Methodologies culminates with the students being assigned their senior capstone design projects and teams. The second course in the sequence is

Mechanical Engineering Design 1. This course takes place during the fall semester of the student's senior year and is the first of the two semesters in which the students work on their senior projects. The fall semester focuses on the design and analysis of the chosen solution. The students formulate their solution, generate hand and CAD drawings of the full system and sub-systems, and perform calculations and computer-based analyses on their systems to guarantee it meets all designated requirements for the project. The final course in the sequence, Mechanical Engineering Design 2, requires the students to complete any supplementary analyses, build and test the prototype of their system, and manufacture a final solution. The course concludes with a design showcase of all of the final products.

The projects at Florida Institute of Technology fall into one of three major categories: industry sponsored, university sponsored, or humanitarian projects. The industry sponsored projects are provided to the university by an industry sponsor and allow the students to experience "real-world" engineering. The university sponsored projects are generated by the mechanical engineering department or the college of engineering. The humanitarian projects are generated based on a need as designated by the student teams themselves. Some previous examples include a manually operated water purifying device and a machine to manufacture shoes from old plastic bottles for third world countries.

Aside from focusing on the design and build of their senior capstone design projects, the students are also required to submit weekly executive summaries and presentations to their advisory committee throughout both semesters of their Mechanical Engineering Design course; the committee is comprised of the course professor, graduate student assistants (GSAs), and industry or university sponsors.[1,7,16,17] The weekly presentations are given to ensure the project health, as well as to provide the students with a platform to practice their presentation skills in a semi-formal environment and prepare for their formal presentations. The end of the student's fall and spring semesters of senior year culminate in a Preliminary Design Review (PDR) and Critical Design Review (CDR), respectively. Each of these milestones require the students to submit a technical report outlining their design and processes, and a comprehensive presentation to their advisory boards.

2.2. Motivation Factors

Pintrich identified the importance of motivation on academic performance.[10,18,19] The MSLQ is a widely used tool in the academic community to measure student motivation. The students are required to self-assess their motivation on a seven-point Likert scale, with a value of 1 corresponding to "not true to me at all" and a 7 corresponding to "very true to me". A value of 4 is accepted as neutral and the other values are a gradient between the aforementioned digits. The five factors observed in this study are cognitive value, self-regulation, self-efficacy, intrinsic value, and anxiety.

Cognitive value describes the ability to recognize the competencies and sequence of events necessary to complete a task and self-regulation is the student's ability to organize themselves to do so successfully.[18,19] Self-efficacy is the student's self-confidence in their ability to achieve a goal.[20,21] Intrinsic value is similar to self-efficacy; the difference is that intrinsic value includes the interest that the student possesses in the task and their perception of the benefit of having a specific outcome.[7,9,19]

Anxiety is specifically looked at with regard with presentation anxiety. Recall, this is due to the fact that the senior capstone design teams are required to give weekly presentations to their advisory committee. The advisory committee consists of the course professor, graduate student assistants, and any industry representatives that oversee the project. The students are also required to present a PDR at the end of the fall semester and a CDR at the end of the spring semester at the conclusion of the project. If the students are not confident in their presentation skills, these events have been identified to be a source of anxiety.

2.3. Student Demographics

Studies have suggested that demographics impact the motivation and performance of students. The authors request the participants of the quantitative study to provide their demographic information for comparison. The demographics considered by the authors are gender, age, residency (domestic or international student), family income, and the highest degree obtained by the student's parents. The authors also consider the student's GPA and whether or not the student had transferred into Florida Institute of Technology to see if these factors impact the student's motivation.

2.3.1. Student Gender

Even though the statistic reached a ten-year high in 2017, women still only accounted for 21.3% of all undergraduate engineering degrees.[22] The lack of female students in science, engineering, technology, and math (STEM) fields has been attributed to many different causes, including the gender stereotype that these fields are masculine fields. Other causes discussed by literature are: lack of female role models[23–25], lack of outreach to young girls[26], and the self-perception of the inability to succeed in these fields and low self-efficacy due to their gender[27]. While these issues can cause females to avoid entering the sciences altogether, there are also difficulties with the retention of female students upon entering a STEM field.[28] Women are 2.5 times more likely to leave a STEM field after entering university level study.[20,29] Shih, et al. showed that motivation can shift, causing women to change their identification within the field.[30] This change in motivation can make the female students feel uncomfortable within their field, causing a "disidentification"[29,31,32] as a scientist. The females tend to shift to other, more empathetic fields where they feel comfortable.

2.3.2. Student Residency

Only 10.1% of all of the engineering degrees awarded in the United States in 2017 were awarded to students of international descent.[22] Depersonalized instruction has been revealed to cause students to disidentify with their field of study[33]. This is a threat for international students due to factors including language barriers and cultural disparities. Studies have identified that language barriers cause international students to have trouble assimilating to a project based environment, due to the necessity to communicate as a team. The students may understand formal English as taught for their proficiency exams, but have trouble communicating in an informal environment.[34,35] This is further exacerbated by the need to make formal presentations to their advisory committee, causing anxiety for the students and pushing them away from a lead position.[35] International students face cultural disparities, while also being required to integrate into university level curriculum both academically and socially. Studies show the two concepts to be interrelated[36]; therefore if international students have trouble assimilating socially, their academic performance will be impacted as well. On the contrary, if international students are having trouble integrating themselves into the academic environment due to depersonalized instruction, they are more likely to remove themselves from their peers.

Florida Institute of Technology has one of the largest international student populations in the United States (34% of the student body and 40% of the engineering student population), affording the ability to observe motivational differences based on the student's residency. In this study specifically, the cohort is 60% international; this is outlined further in the explanation of the study. This allows for a unique analysis of the differences between the domestic and international student populations, as most studies in the literature focus heavily on the domestic student populations, with a small sample size of international students.

2.3.3. Family Socialization

Tinto hypothesized and studied the effect of the parent's education and socioeconomic status, as well as their expectation of the student, on the student's motivation and performance.[37] One study of Tinto's suggested that higher social status produced a higher aptitude on standardized tests,[38] whereas the opposite equally applies. This disparity stems from a student's early education and propagates through the student's academic tenure. A study by Gut, Reimann, and Grob confirmed prior research that children with low socioeconomic status and family expectations tend to perform poorly compared to students that have parents with higher status and a higher expectation of their competence.[39] At the university level, socioeconomic status impacts the student's performance on multiple levels. Students from lower income families tend to consider a cost-benefit tradeoff of attending university due to the high costs associated with going to college.[40] This can also result in student attrition after entering university and seeing the costs associated with their attendance. This likelihood of attrition is further exacerbated if the student is ill-performing. Family expectations affect the student's outlook on education from an early age, as well. If the student's parents attended higher education, the student is more likely to distinguish attending university as the norm due to their parent's success.[38] Students with families that attend university are also more likely to receive attention and support regarding their education.[41]

2.3.4. Previous Student Performance

The study performed also accounted for the student's previous educational experience through the use of the student's cumulative GPA and whether or not the student had transferred into Florida Institute of Technology or had been there through the duration of their undergraduate tenure. While multiple studies have suggested that GPA is a flawed determination of the student's performance at the university level,[42–44] others have shown that GPA tends to be consistent across semesters.

[45,46] Students that have higher GPA's are generally expected to maintain a higher GPA, while students with a lower GPA tend to maintain a lower GPA. Therefore, the authors view the student's cumulative GPA with respect to their motivation levels and performance to see if a correlation exists.

With the rising cost of tuition at the university level, more students are taking courses at lower level colleges and transferring into university for their intermediate and higher level courses. Studies have also been conducted to determine the impact of transferring into university, versus attending university for the standard, four-year trajectory. A study by Dills and Hernandez-Julian found that students who transfer into university tend to perform poorly in their intermediate courses compared to students that enter university at the freshman level. While the difference was found to be small, it was statistically significant.[47] Another study by Sinha found that students that transfer into an undergraduate STEM program take longer to graduate than those that begin their program and finish their program at the same university.[48]

3. Research Method

This research observes the impact of student motivation on performance in senior capstone design. The study is performed using quantitative and qualitative input from the cohort of students. The quantitative data is collected through the use of a modified version of Pintrich's MSLQ at two instances in time: the beginning of the fall semester of the students' senior year and the end of the spring semester of the students' senior year. The qualitative data was collected in the spring semester of the students' senior year, after the conclusion of the senior capstone design course. The qualitative data serves to further explain the students' performances.

3.1. Study Subjects

The study subjects were all students in senior capstone design during the 2017-2018 academic year. There were a total of 88 students enrolled in the senior capstone design course. The demographic information for these students is provided in Table 1. The total population is 87.5% male and 12.5% female. Approximately 40% of the population are domestic students, while 60% of the seniors are international students.

Table 1: Senior Demographic Information

	Domestic	International	**Total**
Males	28	49	77
Females	7	4	11
Total	**35**	**53**	**88**

In order to draw direct comparison, only the students who completed both MSLQ surveys and the qualitative exit interview were considered. This reduces the student cohort size to 80 students. The demographic information for the students is shown Table 2. In the normalized cohort of students, 87.5% are male and 12.5% are female. The international population of students is larger than the domestic population: approximately 59% and 41%, respectively.

Table 2: Cohort Demographic Information

	Domestic	International	**Total**
Males	27	43	70
Females	6	4	10
Total	**33**	**47**	**80**

3.2. Quantitative Analysis

The quantitative data collection was administered at two instances in time: the first MSLQ survey was disseminated at the beginning of the fall 2017 semester, before the students had begun to work on their senior capstone design projects; the second MSLQ survey was disseminated at the end of the spring 2018 semester, after the students had completed their senior design projects. The MSLQ views five motivation factors: cognitive value, intrinsic value, self-regulation, self-efficacy, and test/presentation anxiety. Each of these five motivation factors are compared to the student's performance in the senior capstone design course, which is measured through the use of the student grade for the fall and spring semester. This addresses RQ1: *Does a correlation exist between motivational factors and student success during each individual semester of Senior Capstone Design (fall and spring)?* The student's demographic information is also taken into consideration to determine if trends exist within demographics or between demographics. The delta in the motivation factors is also compared to the change in the student's performance throughout the course to address RQ2: *Does a correlation exist between motivational factors and the change in student success over the course of the two semester senior capstone design course?* The change in the student's motivation is compared to the change in the student's final grade between the fall and spring semesters of senior capstone design, to determine if a relationship exists. This is again considered with respect to the student's demographic information to determine if trends exist within or across demographic groups.

The quantitative data is analyzed using two statistical methods – t-tests and linear regression – to compare subjects and correlate them to relevant variables. The linear regression seeks to determine if there is correlation between the hypothesized independent variables and the dependent variable (student performance). The analysis utilizes Akaike's Information Criterion (AIC) to find the best fit model since correlations may be multi-level.[49] Paired t-tests are also performed between the student's fall and spring MSLQ data. Significance is considered to exist at an $\alpha < 0.05$, however $\alpha < 0.10$ is maintained for discussion.

3.3. Qualitative Analysis

The authors implemented a qualitative interview at the end of the senior capstone design sequence to gain insight into possible motivation factors. This qualitative study was performed at the end of spring semester 2018, as the students were finishing up their respective senior capstone design projects. Each of the nine student teams were requested to perform a group exit interview regarding their experience in senior capstone design. Some of the questions inquired to student groups were focused and targeted with regard to their motivation factors: "Were you motivated to do well in this course? If so, what were you motivated by?" Other questions were not as direct, but were intended to gain insight into the student's choice of senior design teams and future goals: "Do you intend on going to industry or continuing your education after graduation? Did senior capstone design play any role in this?" and "Do you feel more confident in your ability as an engineer having completed this course?" This interview was implemented to address the secondary goal of the research, RQ3: *Can qualitative data collected via a team interview format provide insight into specific variables impacting student motivation and performance in senior capstone design* to determine whether the student's qualitative responses could provide further insight into the variables affecting motivation and performance in senior capstone design.

Each of the qualitative interviews by the nine senior capstone design teams were transcribed, and the authors individually extracted the codes from the transcriptions. The result was 69 different codes, each of which were recurring topics from the exit interviews of the students. A few examples of these codes include "teamwork", "potential job opportunity", "skills", and "grades". A coding tree is presented in Figure 5 in the Appendix. The authors used this coding scheme to correlate recurring topics to motivation factors and performance in the course. The Cohen's Kappa coefficient[50] to measure the agreement of the author's codes was calculated to be $\kappa = 0.99$. Any value of over $\kappa = 0.75$ is generally accepted to be excellent[51], while some have arbitrarily suggested that a value of $\kappa = 0.81\text{-}1$ as perfect agreement for the model[52].

4. Results

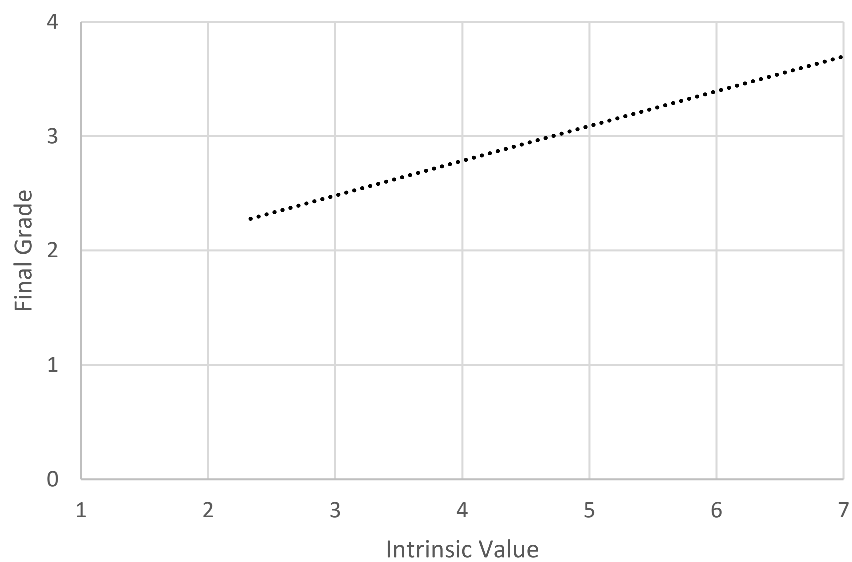
The authors measured the student's performance in senior capstone design with respect to five motivation factors: cognitive value, self-regulation, anxiety (modified to presentation anxiety), intrinsic value, and self-efficacy. The student's demographic information was also considered, including their gender, age, residency, family income, and the highest degree attained by their parents.

The results of the MSLQ were compared to the student's performance in senior capstone design. Recall, the MSLQ is graded on a seven point Likert scale, where a value of 1 indicates "not true to me" and a value of seven indicates "very true to me". The performance metric for the study was the student's final grade in the fall and spring semesters of the senior capstone design course, as well as the delta in the student grade. The student's grades were correlated to a numeric value for comparison, which is reflective of the GPA calculation at Florida Institute of Technology. The numerical values for performance are represented as traditional GPA scoring whereby A=4.0, B=3.0, C=2.0, D=1.0 and F=0.

To supplement the quantitative study results, the authors performed an exit interview with each of the senior capstone design teams. The students were asked a total of 19 questions, in an open-floor, interview type format. The students were instructed to be as specific as possible in their answers. The authors subsequently coded each of the qualitative transcripts to identify recurring factors contributing to the students' motivations and performances.

4.1. Motivation in Mechanical Engineering Design 1 (Fall 2017)

A linear regression was performed for each of the students in the cohort to determine which of the five motivation factors of interest impacted their performance (measured using student's final grade in the course). The students' fall grades were found to be impacted by their intrinsic value, with significance (p=0.0258). Figure 1 shows the correlation between the student's self-reported intrinsic value and performance for the Fall 2017 senior capstone design course. It is important to note that because many datapoints overlap, the datapoints were removed from the plot since overlap could not be visualized.



	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	1.6009	0.8147	1.965	0.0530
Intrinsic	0.2979	0.1311	2.273	0.0258

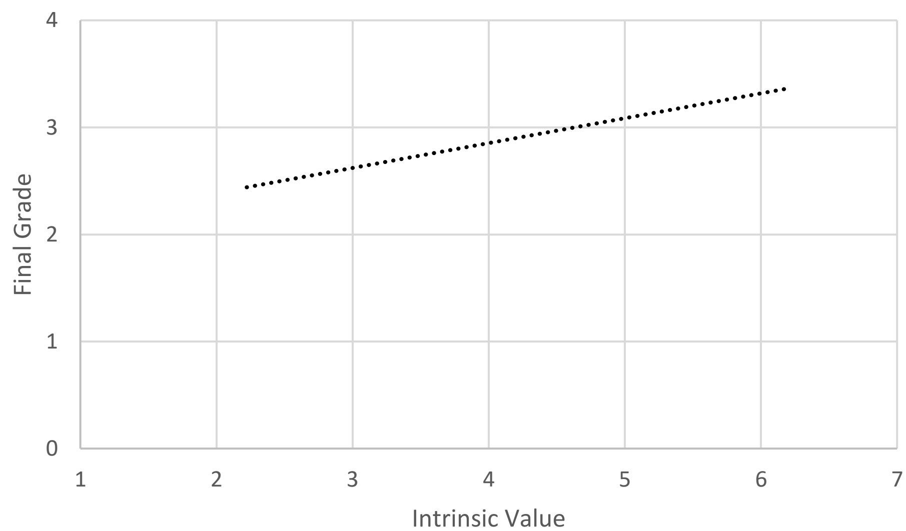
Residual standard error: 0.7441
F-statistic: 5.167
Model p-value: 0.02581

Figure 1: Correlation of Fall Performance to Intrinsic Value

It is shown that students with higher intrinsic value earned higher grades in the course. Recall, the MSLQ surveys were disseminated at the beginning of the senior capstone course, before the students had begun working on their projects. Therefore, students entering with a higher self-confidence in their ability and perception of the importance of senior capstone design performed better than students without. Also, it is important to note that the student's intrinsic values were not impacted by their demographic information, including gender or residency, when entering into senior capstone design.

4.2. Motivation in Mechanical Engineering Design 2 (Spring 2018)

An AIC analysis was also performed using the spring senior capstone design final grades and student's self-reported motivation factors. Again, intrinsic value was determined to be the primary determination for the student's performance. This was further exacerbated by the student's cognitive value. Figure 2 shows the correlation between student performance (measured using course grades) and intrinsic value. It is important to note that because many datapoints overlap, the datapoints were removed from the plot since overlap could not be visualized.



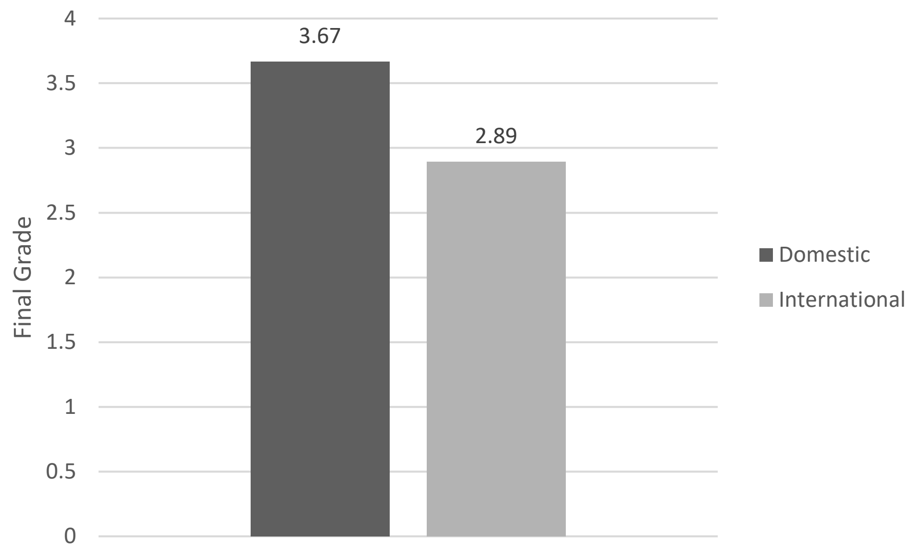
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2.6933	1.0047	2.681	0.00901
Cognitive Value	-0.2726	0.1651	-1.651	0.10296
Intrinsic	0.3363	0.1802	1.866	0.06592

Residual standard error: 0.9841
F-statistic: 2.217
Model p-value: 0.1159

Figure 2: Correlation of Spring Performance to Intrinsic and Cognitive Value

While a p-value < 0.05 was preferred, the authors maintained p-value < 0.1 for discussion. As shown in the figure, the student's intrinsic value was significant to p-value < 0.1 (p=0.06592), however the model p-value was greater than 0.1 at a p-value of = 0.1159.

Interestingly, the research identified that the student's performance was significantly related to the student's residency for the spring semester of senior capstone design. This is shown in Figure 3, below. The domestic students performed significantly higher (p<0.0004) in the spring semester than the international students.



	Domestic	*International*
Course Grade	3.667 ± 0.595	2.894 ± 1.106

Comparison *p-value*: *0.0004708*

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	2.9130	0.1375	21.18	2e-16
Residency	0.7536	0.2128	3.542	0.00068

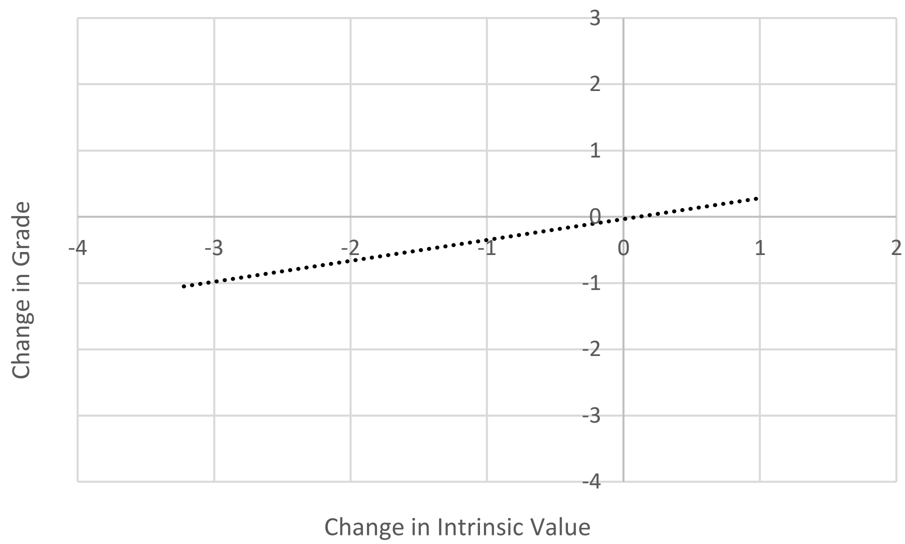
Residual standard error: 0.9327
F-statistic: 12.54
Model p-value: 0.0006784

Figure 3: Comparison and Correlation of Mean Grades to Residency

4.3. Change in Motivation and Performance

The linear regression model for the change in motivation and performance between the fall and the spring semesters showed that the change in the students' grades were impacted by the change in their intrinsic value. While the model did not produce a $p<0.05$ for significance as indicated by the authors, the model value of $p<0.1$ was maintained for discussion. Figure 4 shows the relationship between the change in grade from the fall to spring semesters and the change in intrinsic value. It is important to note that because many datapoints overlap, the datapoints were removed from the plot since overlap could not be visualized.

The model p-value = 0.07127. The trend line shows students that performed poorly in the spring semester of senior capstone design saw a decrease in intrinsic value. However, it is peculiar to note that only students that exhibited an increase in intrinsic value were the students that did not have a change in their grade between the fall and spring semesters; most students experienced a decrease in intrinsic value, even if their grades increased between the fall and the spring semesters.



	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.04722	0.12976	-0.364	0.7170
Intrinsic	0.26717	0.14607	1.829	0.0713

Residual standard error: 0.8148
F-statistic: 3.345
Model p-value: 0.07127

Figure 4: Correlation between Changes in Course Grade to Changes in Intrinsic Value between Fall and Spring Semesters

4.4. Qualitative Results

The authors implemented a qualitative survey to gain further insight into the student's motivation factors and their impact on student performance during senior capstone design. Each senior design team attended an open-floor exit interview which inquired about items that positively or negatively affected their senior capstone design experience. The authors identified 69 unique codes that were realized through the interviews. These codes were generalized into the following themes: selection, process, and results. The "selection" theme primarily focused on the entrance into senior capstone design; this included reasoning behind specific project selections and current and future goals for the students. The "process" theme explored the period of time during senior capstone design. This included the student's challenges and motivation for persistence, as well as the senior design experience as a whole. Finally, the "results" theme generally looked at the outcome of senior capstone design, including any skills and reflections by the students. The three main themes, as well as their sub-themes are shown below in Table 3. This also shows the occurrence of each of the sub-themes. The count is the total number of times that factor was mentioned during the exit interviews with the student teams.

Table 3: Qualitative Factors

Theme	Sub-Theme	Count
Selection	Personal	87
	Previous Experience	21
	Current Goals	19
	Future Goals	24
	Challenges	15
Process	People	127
	Challenges/Motivations	85
	Project Requirements	6
Results	Future	15
	Skills	37
	Reflections	152

The qualitative analysis determined that personal goals had a major impact on student's project selection. While future goals played a role, it was personal thrusts that were referenced when detailing why one selected the project. When referencing the process of the design course, students often referenced the personnel involved, specifically their team mates. The team element of the design experience seemed to have a significant impact on the students' perception of the design process. When discussing the results of the project, students reflected on their decisions and activities often. The reflection is a positive sign as reflection is often a necessary component of learning. Students often reflected on what they would do differently or decisions they made that were later found to be instrumental to their progress.

5. Discussion

The impact of motivation on each of the fall and spring semesters of senior capstone design are presented, as well as the change in motivation and change in grade across the two semesters. Qualitative interview data was also collected to identify key factors for the students' performance, as told by the students.

5.1. Individual Semester Performance and Intrinsic Value

The senior capstone design student's fall performance was found to be correlated to their intrinsic value ($p<0.05$). Likewise, their spring performance was found to be correlated to their intrinsic value, however the model lacked significance ($p=0.1159$). The student's intrinsic value is their confidence in completing the task at hand and their recognition of its significance for their learning. The students that recognized the significance of the course tend to outperform the students that do not.

An interesting finding was that the student's fall performance was not affected by their demographic information, however their spring performance was impacted by their residency, with significance. The domestic students received higher grades in the spring than their international counterparts. Studies have identified that social integration can be problematic for international students;[36,53] this includes language barriers that may exist, making it difficult for them to understand colloquial English in informal environments.[34,35] This is challenging for the students, especially in a group environment such as senior capstone design. Likewise, studies have shown that the international students have a difficult time succeeding in courses requiring the students to give formal presentations, which is true in senior capstone design.[9,36,54] During the qualitative data collection, international students often cited the nontraditional mode of course presentations instead of traditional course learning modes (sitting in class or laboratory). Further, international students expressed concern that their limited English-speaking ability may adversely affect their team.

It was also found that the student's intrinsic value decreased overall from the beginning of the fall semester of senior capstone design to the end of the spring semester of senior capstone design. A t-test comparison was performed to observe the change in intrinsic value between the fall and the spring semester of capstone design. As detailed in Table 4, the intrinsic value decreased significantly from approximately 6.19 to 5.55 to a p-value<0.0001.

Table 4: Intrinsic Value Paired T-Test Results

Intrinsic Value	***Fall***	***Spring***
Mean	6.1889	5.5472
Standard Deviation	0.4108	0.4559
Pearson Correlation	0.5309	
t Stat	8.9935	
p-value	1.0e-13	
t Critical	1.9905	

In addressing the first research question - *does a correlation exist between motivational factors and student success during each individual semester of Senior Capstone Design* - the authors find that a positive correlation exists in each of the semesters, where an increased intrinsic value indicates increased performance; this correlation is significant in the fall semester, but insignificant during the spring. While this relationship is further exacerbated during the spring semester by the student's cognitive values, it still does not produce a significant model.

5.2. Changes in Performance and Motivation

The student's change in motivation levels was observed with respect to the change in their final grades between the fall and spring semesters of senior capstone design. The authors found that the change in the student's intrinsic value was correlated to the change in their grade (p<0.07127). However, as discussed, the students' intrinsic values decreased with significance between the fall and spring semesters of senior capstone design.

In addressing the second research question - *does a correlation exist between motivational factors and the change in student success over the course of the two semester senior capstone design course* - the authors find that the change in intrinsic value between the two semesters is correlated to the change in final grade of the cohort. While this correlation was found to be significant, many of the students experienced a decrease in intrinsic value. The only students that experienced an increase in intrinsic value did not see a change in grade between the fall and the spring semesters.

5.3. Qualitative Interview Feedback

The 69 unique codes identified in the student interviews were segmented into a tree with the three overarching themes being:

- Selection - prior to entering senior capstone design,
- Process - during the process of senior design, and
- Results - goals and factors at the completion of senior design capstone design.

Selection saw the students most concerned with their personal goals, having an occurrence of 87; process was concerned with the people sub-themes with an occurrence of 127; results were influenced by reflections with an occurrence of 152.

Selection- The *personal* goals identified by the students included the subcategories of:

- Desirability of project
- Interest in project
- Competition project
- Industry project
- Confidence
- Desire to design
- Desire to help

Entering into senior capstone design, the students were primarily concerned with their choice of project. This included their desire and interest in their project choice, including their choice of participating on a competition or industry sponsored project. The students also identified their desire to help and design. These results are consistent with the quantitative results from prior semester; indicating the student's performance was impacted by their intrinsic motivation. The students recognized the importance of the task at hand and were confident in their abilities to complete their project. The students that indicated that project choice was important generally spoke of the prospective impact of their project. For example, many of the industry teams indicated that their project choice was based off of the possibility of getting a job with that company post-graduation. The students were cognizant that their performance in the course and on their project could successfully result in a career with that company.

Process- The *people* subcategory included a multitude of subdivisions that were grouped into:

- University resources
- External resources
- Team

The university resources included personnel within the department (the professor, graduate student assistants), the machine shop instructors, and our student design center's assistants. External resources were identified by the industry sponsored teams as their appointed industry representative. The team category specifically looked at the members of the team and their skillsets, team dynamics, and communication.

Results- The *reflections* subcategory of results included the subcategories of:

- Good experience/consistent project choice
- Learning
- Application of previous courses
- Graduate school motivation
- Success on other teams
- Change of project choice
- Desire for prerequisites

At the conclusion of senior design, many students indicated that they had a positive experience and had felt that they had learned many skills throughout the course of senior design. Moreover, students indicated they would choose the same project again if they were to do it again. Students recognized the need to apply their previous coursework during to ensure successful project completion. Some students indicated their desire to attend graduate school due to their experience in senior design. Also, some students indicated that they were confident that they could have been successful on any other senior design team having acquired the necessary skills.

On the other hand, some students indicated that they felt that they would have been *more* successful on a different senior design team and would change their project choice if they were given the chance to start senior design over again. A few students indicated that there should be additional introductory and prerequisite courses required before entering into senior capstone design because they felt that they were ill-prepared for the professional standards needed to succeed. The authors hypothesize that responses such as these could be an indication as to why the student's intrinsic value decreased over the two semester sequence. The students entered senior capstone design confident in their ability to complete their design challenge and perform at an industry level. The experience of senior design allowed for the students to reflect on their strengths and weaknesses, and identify possible areas of improvement in their skills; this includes technical skills and competencies as well as professional skills and competencies.

In addressing the third research question - *can qualitative data collected via a team interview format provide insight into specific variables impacting student motivation and performance in senior capstone design* - the authors believe that the qualitative student interviews provide insight into the quantitative results, such as the decrease in intrinsic value between the two semesters of senior capstone design.

5.4. Limitations of the Study

The primary limitation of the study was the ability to gather qualitative data from each of the students in the senior capstone design course. Given the size of the senior design class, it was not possible to schedule and perform comprehensive individual student interviews. Therefore, the qualitative exit interviews were administered on a by-team basis. This resulted in nine, thirty minute interviews with each of the senior design teams. This provides a snapshot of the variables impacting student motivation and performance. However, some of the students did not get the chance to participate at all, or did not feel comfortable disclosing this information in front of their colleagues. To try to mitigate these effects, the authors provided each participant with the list of interview questions and contact information for the authors; this was intended to allow for the students to expand upon some of their answers or disclose information in a private setting. While some students did take advantage of this opportunity, it is not certain that all possible factors were extracted for review.

The data was only collected at two instances in time: before the students began working on their senior capstone design projects and at the end of the student's senior design experience. While the authors intentionally designed the study this way to prevent survey fatigue, it may be insightful to include an additional survey between the two semesters of the course to gather data from the students while they are fully engaged in their projects. It also may be beneficial to collect qualitative data from the students at the start of their senior capstone design experience. The qualitative data was only collected once the students had completed their projects, requiring them to answer some of the questions in a reflective manner.

6. Conclusion

This study examines the impact of motivation factors on student performance in senior capstone design. The motivation factors observed in the study are cognitive value, self-regulation, anxiety, intrinsic value, and self-efficacy. Quantitative data collection occurred at two points in time: the beginning and end of the student's fall and spring semester of senior capstone design respectively. Qualitative data was also collected through the use of team-based exit interviews at the conclusion of the senior design course. The study identifies that the student's fall, spring, and delta (changes between fall and spring) correlated to various motivational factors, as measured by the MSLQ. When considering course performance, grades were also found to be correlated to motivational factors, indicating that motivation toward the design course may impact how students perform. A t-test was also performed to examine the change in intrinsic motivation between the two semesters. It was found that the student's intrinsic motivation drops, with significance, between the two semesters. In an attempt to determine what may cause students to be motivated toward the senior design capstone course, a qualitative data is collected through the form of interviews and a coding scheme is developed based on the findings.

6.1. Future Work

Suggested future work includes the refinement of the qualitative survey to allow for effective questioning. While the survey was proven to be robust and provided effective feedback for the authors with respect to the changes in motivation factors, the initial feedback from the student can be used to tailor the survey to efficiently gauge student motivation. For example, one recurring topic in the qualitative interview was the importance of the graduate student assistants for the team. The GSA's would provide extrinsic motivation for the students. Extrinsic motivation has been shown to impact intrinsic motivation.[55] Therefore, the graduate student would be a factor affecting the student's intrinsic value. The authors can use this feedback to tailor the surveys further toward the motivations factors being measured in the study. The qualitative surveys will also be coded and correlated to specific motivation factors.

The authors also intend on implementing a qualitative entrance interview for the students. Rather than asking the students to consider their experiences in retrospect, the authors see the importance of inquiring about the student's expectations of the senior design course in real time, before the students are exposed to the course. The authors realize that some of the questions that were asked of the students in retrospect could have produced skewed answers due to the students having completed senior design. Therefore, the students knew the overall outcome of the course and adjust their answers accordingly. For example, some of the higher performing teams in senior capstone design reported less anxiety than the teams that performed poorly.

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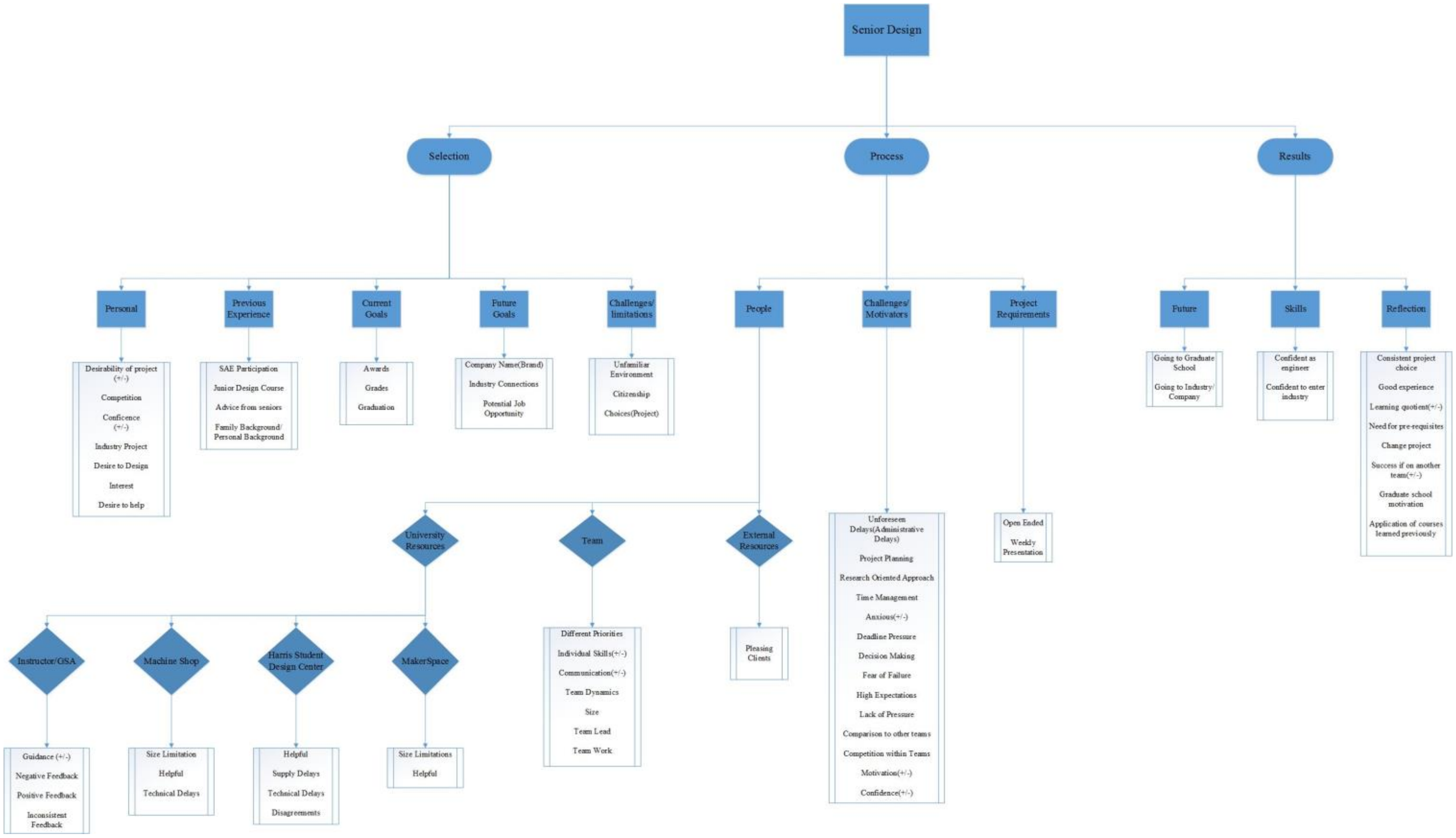

Figure 5: Coding Tree of Coding Scheme Developed