International Journal of Engineering Education Vol. 35, No. 3, pp. 779–794, 2019
Printed in Great Britain

0949-149X/91 $3.00+0.00

The Implementation of an Intervention Plan to Improve Student Motivation and Performance in Mechanical Engineering Senior Design Capstone*

ELISABETH KAMES and BESHOY W. MORKOS**
Department of Mechanical and Civil Engineering, Florida Institute of Technology, Melbourne, FL, USA.
E-mail: ekames2011@my.fit.edu, bmorkos@fit.edu

AMANDA BESSETTE
Systems Engineer, FIRST Robotics, Manchester, NH, USA. E-mail: Abessette@firstinspires.org

Motivation and performance play an integral role in the success of engineering students at the collegiate level. Professors face challenges between the diversity of the students and diversity in engineering disciplines, creating the need to reform education in the field of engineering. The purpose of the study is to identify motivational changes and implement an intervention plan incorporating strategies, discussions, and approaches to adapt the educational system to work for an assortment of student populations. The study uses an adapted version of the Motivational Student Learning Questionnaire (MSLQ), to measure the motivation of two different cohorts of students throughout capstone design courses in comparison to their respective performance. The five motivation factors studied were: cognitive value, self-regulation, presentation anxiety, intrinsic value, and self-efficacy. Statistical Analysis was performed between the motivation factors and demographic populations of the students (male vs. female, domestic vs. international), as well as within populations. The first cohort of students were the control cohort, experiencing the typical senior design capstone requirements. The second cohort of students experienced the implementation of an intervention plan to better prepare them for the senior design capstone sequence. The intervention plan entailed changes made to Design Methodologies, a precursor course to capstone completed during the junior year. This research will evaluate whether these changes affected the students' initial motivational levels among different demographics. It is important to note that the changes made to Design Methodologies were not related to the content of the course; rather the changes were intended to better familiarize the students with their upcoming tasks and goals for senior design capstone.

The findings of the two-year longitudinal study comparing motivational factors and performance of the two mechanical engineering senior design capstone course cohorts are presented: the control cohort using the standard teaching methods for Senior Design Capstone at the university and the test cohort undergoing the intervention plan in the curriculum. The results show that the intervention plan made a positive impact on the student factors, especially for the international student population. More importantly, the intervention plan focused on promoting positive reinforcement regarding motivational factors rather than negative reinforcement.

Keywords: design education; senior design; capstone design; student motivation

1. Introduction: student motivation in senior design capstone

Often a final requirement before graduation, senior design capstone is recognized as a defining moment in an undergraduate engineering degree. Commonly shortened to "capstone", the design course integrates practical application of the theoretical knowledge acquired throughout their undergraduate education. Capstone design features a team project format, allowing students to experience professional engineering design problems. This experience allows students to develop their understanding and prepare for the next step in their career, whether it be continuing education or exploring industry. This study investigates the impact of the implementation of an intervention plan on the correlation of student motivation with performance in senior design capstone. As a critical curriculum component, it is important to identify the reasons behind student performance in senior design capstone. This study will evaluate and analyze student motivation throughout senior design capstone within the Mechanical and Aerospace Engineering Department at Florida Institute of Technology. The diverse population at this university affords a unique opportunity to compare student motivation in each of the cohorts, in terms of the domestic and international (who comprise 40% of the college of engineering at the university) students. The goal of the study was to identify whether the implementation of an intervention plan, designed to better prepare the students for senior design capstone during their junior year of undergraduate education, had a positive impact on the student's motivation and performance through-

** Corresponding author.

* Accepted 20 January 2019.

out the course of senior design capstone. A subsequent goal of this study was to identify if motivational differences exist between students' demographics (international versus domestic and males versus females) within the sequence of senior design capstone and how these motivational differences affect student performance. Performance metrics for this study include team grades and individual grades.

Data collection follows two separate years through the senior design capstone course. The first cohort group is the control group, with only observations being conducted. The second cohort, the test group, was affected by an intervention plan and observed throughout the senior design capstone duration. The intervention plan was designed to address the motivational deficiencies observed in the control cohort. Performance metrics (team grades and individual grades) were utilized to determine if the intervention plan yielded a positive change in any of the measured motivational factors. The authors created an adaptation of the Motivated Student Learning Questionnaire (MSLQ), inspired by Pintrich's study on middle scholars, to measure motivational elements of senior design capstone students. The MSLQ instrument, widely used within the education community, will be explained in detail in a subsequent section.

1.1 Introduction: intervention plan

With the hypothesis that motivation will impact the performance of students in senior design, the authors set out to develop an intervention plan that would address the five factors considered for motivation (self-efficacy, self-regulation, cognitive value, test anxiety and intrinsic value). The intervention plan was implemented both before the start of senior design, in a precursory Design Methodologies course, and throughout the senior design two semester course [1]. The control cohort of students did not experience an intervention plan; the courses were conducted as they previously had been at the university.

Extrinsic motivational elements were incorporated during the course to help students improve their intrinsic value. This is supported by prior studies which show an effective ways to impact intrinsic motivation is through external stimuli [2]. Extrinsic motivation was implemented through multiple modes including verbal, numerical, and physical. For example, a verbal external motivation could be positive feedback from a professor and a physical motivation could be winning a gift card for best presentation [3]. The frequency of professor (or graduate student assistant) feedback to students on their progress was increased and incorporated throughout the course. Further, awards were given to students based on their presentation and documentation quality at the end of the year. This added additional motivation for students to perform well on those specific categories. Contrary to the previous method of providing feedback during the end of the semester, spreading feedback throughout the semester provided students the opportunity to gain motivational spikes throughout the courses.

Anxiety was experienced by the students in the form of presentations, as the course did not include homework or examinations. Presentations were performed weekly to faculty and graduate student advisers and were the basis for grading throughout the semester. In this study, presentation anxiety is the anxiety felt when speaking in front of an audience. Since those presentations were given to an audience of individuals who assign their grades, the anxiety was high among students, particularly international students. To address this concern, students were afforded the opportunity to meet with their graduate student assistant to practice and discuss their presentations. The session with the graduate assistant allows for an open environment, where the students were under less pressure and felt more comfortable asking questions [1].

The ability to organize oneself for success without external intervention or distraction is known as self-regulation [4, 5]. While some students require the assistance of planners or checklists to orchestrate tasks, others are able to do it mentally. In order to improve the self-regulation metrics of various students, the course required teams to submit weekly executive summaries to their advisory boards [1]. The executive summaries outlined the tasks that were accomplished for the week, the planned tasks for the following week, as well as an analysis of the project and budget health.

Similar to self-regulation, cognition is the mental action of acquiring and processing thoughts or requirements [5]. Due to their similarities, the intervention plan addressed cognition in a way that was comparable to self-regulation. Students used the knowledge obtained in Design Methodologies to recognize and document the requirements for their project to determine feasible goals and deliverables for the year. The student teams were required to submit an updated weekly requirements list to their advisory boards to outline the progress toward their project goals or objectives. It is important to note that cognition and self-regulation are independent factors, despite their similarities [1].

Self-efficacy is the ability to realize the competency required to complete a goal [1]. This differs from intrinsic motivation, as self-efficacy is the confidence necessary to complete a goal; intrinsic motivation entails the motivation necessary to com-

plete a goal [6]. The students obtain the necessary knowledge to succeed in senior design capstone through Design Methodologies, the precursory class. However, the students must possess the ability to apply to this knowledge in order to succeed. Through the intervention plan, the school's Career Management Services office introduced external industry guest speakers in order to provide external validation to the students. The speakers outlined the hiring process, success skills, and real world engineering challenges [1].

A detailed explanation of the intervention plan for Design Methodologies is provided in Section 3.3.

1.2 Motivation

A common feedback from employers regarding new engineering graduates is the inability to communicate and function within a team setting [7]. Courses such as senior design capstone aim to bridge this gap through project based learning. The goal is to minimize the learning curve as students matriculate from technical courses to team project oriented tasks [8]. While some students thrive in senior design capstone courses, others struggle to adequately contribute within the course and their team. It is important to identify the cause for this disparity, which could be the result of motivational differences within the student population.

Academic success requires a combination of intellectual ability and motivation [9, 10]. Unlike abilities which can be assessed, motivation is a dynamic, complex phenomenon that needs to be evaluated qualitatively [9]. There are different manners in which motivation is experienced, making it necessary to study the relationship between student motivation and academic performance. Motivation is a contextual and domain specific trait [9]. Therefore, learning environment affects student motivation. Academic success is greatly influenced by the student's personal views on learning and motivation. It is the purpose of this research to determine if and how motivation may impact performance in senior design capstone courses, as its importance is recognized by industry.

2. Background: senior design capstone and student motivation

The expectations of a practicing engineer in industry are incomparable to the education of students in the classroom. Engineers work in an unpredictable environment solving dynamic problems, whereas students are taught in an answer-in–the-back-of-the-book manner [11, 12]. Additionally, students learn in a compartmentalized manner, where courses are completed in sequence over semesters and each semester emphasizes a specific fundamental principle. In industry, graduates may utilize several diverse fundamental principles of engineering in one setting (e.g., dynamics and heat transfer). Moreover, engineering requires the final design meet technical requirements, satisfy customer needs, and solve societal issues [13]. Senior design capstone is able to duplicate this experience, as its core purpose is to integrate all the student's courses into one culminating design project.

2.1 Senior design capstone

Senior design capstone is commonly a final requirement for graduation in most universities' engineering curricula. The capstone projects come from a variety of sources and may be university-based projects or industry-based. Both project types allow for students to solve a problem or eliminate an existing design deficiency.

The length of senior design capstone may vary from institution to institution. Typically occurring within the final year, capstone may bridge one, two, or three semesters; some universities' capstone courses are a combination of quarters. In most institutes, capstone is modeled to simulate real world environments, either research or industry [14–16]. The projects are normally team oriented to increase the number of positive educational outcomes [17, 18]. The size of each team is dependent on the project type and scope [14, 16, 19–21].

Project types and sources vary depending on the institution. Some project sources include design challenges from industry, the engineering department, or engineering society design competitions. Industry sponsored projects may be companies seeking new or more affordable solutions. These projects tend to be more popular as students feel they can make lasting impressions on the sponsoring company [1, 14, 16, 22–24]. Engineering society design challenges include the Society of Automotive Engineering's (SAE) Formula competition, Baja competition or Human Powered Vehicle competition [14, 16, 22, 25].

At semester's end, students present various deliverables as part of the project completion. Deliverables usually consist of a working prototype and supporting documentation. Performance within a senior design capstone course is determined through a combination of instructor and peer evaluations, and the team's ability to meet the requirements initially set for their respective project [14, 16, 19, 21, 26].

The central objective of senior design capstone is to provide a thorough study of the mechanical design process to prepare students for their professional careers. At course completion, students will be equipped to address any design problem related to mechanical engineering. Though the focus of this

course is the mechanical design process, students also gain exposure to content including, but not limited to system modelling, geometric dimensioning and tolerancing, documentation, verbal presentation, contemporary and societal issues, and engineering ethics.

2.2 Gaps in student motivation research

Though the importance of senior design capstone is well known due to its recognition as a defining milestone in an engineering degree, many research questions exist regarding its education efficacy to the students. The first gap is that engineering education heavily groups engineering students into a certain learning styles and motivational levels [27–29]. However, engineers possess different ambitions, and may be motivated by different things [16, 27, 30]. Inadequate scientific research has been conducted on the motivation levels of engineering students with regards to the factors that affect their motivation. Many studies link all students as similar learning styles, as if they are all one type of engineer [31]. In the Academic Pathways Study, individual motivation is not the same between two student engineers [17] including within different sub sections of engineering. Positive motivation keeps the student involved and on a successful path to completion. This motivation may change between the beginning and end of the engineer's academic tenure, and is one of the outcomes this study hopes to demonstrate.

Motivation has been identified as a key factor in the success and retention of university students [32]. A major concern with motivation is that it is not a binary phenomenon. It is not probable to classify a student as motivated or unmotivated [10]. To define success, one cannot just make a student motivated, but has to improve the motivation for a point of time. To study this, a researcher would need to study a group of students in a common year or class (e.g., senior, freshman or junior). At most schools, engineering students do not complete their curriculum requirements in the same trajectory. Students may fail courses, leave for a semester, complete an internship or coop, or have a medical withdrawal. Thus, it is difficult to collect data from the same set of cohorts every year throughout the students' engineering education tenure. The first step in enhancing the motivation of students to identify students' changes in motivation throughout the course of the curriculum. Ideally, motivation should remain the same or increase to bring the student to a successful completion. A decrease in students' motivation may demonstrate an area needing to be addressed to retain students. This means that a time-lapse study of motivation is limited to approximately three timestamps: second semester juniors enrolled in design methodologies, first semester seniors beginning their respective senior capstone design, and second semester seniors at the completion of their senior capstone design. The research covered in this paper investigates the motivation within senior capstone design. However, future works discussed in this research detail the need for a longer, longitudinal study among the same cohort group; this spans from the students' first year through their final year. Positive motivation keeps the student involved and on a successful trajectory toward completion. Studies have shown that students need motivation to do well in school, as well as the basic knowledge to accompany that [10, 33]. Lack of motivation results in delays and switching majors, or leaving school entirely. Previous research shows that there are multiple ways to motivate the general student, but not as to an understanding of the individual factors that motivate those students. Popular factors that affect motivation have shown to be self-efficacy, attributions, intrinsic value and the goals of the student [33]. This motivation may change between the beginning and end of the engineer's academic curriculum, and this research aims at capturing the student's motivation during their last educational year, as the completion of the degree approaches.

The goal of this study was to observe the motivation of the students and eventually target specific factors to find use of motivation as an enabler for success [28]. Five factors were pulled from Pintrich's version of the Motivated for Learning Strategies Questionnaire (MSLQ) [15]. Pintrich's factors are:

1. Test anxiety: The nervousness of pressure perceived when taking an exam.
2. Intrinsic motivation: internal self confidence.
3. Self-efficacy: The belief that one can achieve a goal.
4. Self-regulation: The ability to structure oneself to complete a goal.
5. Cognitive value: The ability to recognize the tasks required to complete a goal [5].

3. Methodology

A case study was administered over the span of two senior design classes to observe the motivation differences between two cohort groups. For this study, motivation was studied over two subsequent years to observe differences between the control cohort of students and the test cohort of students; the test cohort was exposed to an initial intervention plan to increase student motivation. All students from both cohorts were enrolled in mechanical engineering senior design capstone during the observational period [1, 16]. Both years were

taught by the same professor. Both cohorts of students were assumed to have the same incoming abilities, as they have been exposed to the same coursework prior to senior design capstone.

3.1 Cohorts sample

Two senior design capstone cohort classes (Year 1, Year 2) were compared and analyzed. The Year 1 students enrolled in senior design capstone were the control cohort whereas the subsequent year enrollees to whom the changes were administered are denoted as the test cohort. All participating students were undergraduate mechanical engineering majors within a year of graduation. The population was diverse; the student's demographics range domestically and internationally. Each year constitutes an independent cohort since there was no overlap of participants. The demographics of the study are detailed in Tables 1 and 2 [1, 16].

As shown in Table 1 and 2, the two cohorts' sample sizes are similar to allow for the comparison between the domestic and international students. Moreover, comparisons were also made between genders within and between both cohort groups.

3.2 Performance metrics

Performance metrics are measures of the student's success in the class. In senior design capstone, grades are determined through presentations, reports, and final products. As a two semester course, the first semester grading is determined through a combination of weekly presentations, weekly executive summaries, and a final presentation and report. The second semester is similarly graded, with an emphasis on the final product and associated deliverables. The final product must meet the requirements that each team and client set forth in the beginning of the year. The professor and advisory committee select a team grade based on the team's success in delivering a satisfactory design solution. Each individual's grade is then determined through a combination of the team grade and peer evaluations completed by the student's teammates. The peer evaluations are administered at the conclusion of each semester. It is important to note that in this study, both the overall team grade and individual grade (which incorporates peer evaluation) were considered during analysis.

Table 1. Control Cohort Demographics

	Domestic	International
Females	4	5
Males	24	19

Table 2. Test Cohort Demographics

	Domestic	International
Females	5	1
Males	38	36

3.3 Intervention plan implementation

The senior design sequence at Florida Institute of Technology includes three courses: Design Methodologies, Mechanical Engineering Design 1 and Mechanical Engineering Design 2. Design Methodologies takes place during the spring semester of junior year. This course serves to introduce students to the design process and provide necessary competencies to excel in their senior design capstone projects. Mechanical Engineering Design 1 and 2 take place in the student's senior fall and senior spring semesters, respectively. The fall semester course focuses heavily on defining the requirements of the project, ideation, CAD, and analysis of the design; this culminates to the Preliminary Design Review, in which the team compiles a report and a presentation for their advisory boards. The spring semester focuses on generation of a final design, prototyping, testing, and manufacturing of the final product; this culminates in the Critical Design Review, with a full report on the project and final presentation.

The intervention plan implemented makes changes to all three courses of the senior design sequence. While the curriculum remained the same, Design Methodologies was reworked to focus on the generation of requirements and the requirement fundamentals. Starting in March, the juniors were required to attend one senior capstone design presentation per week for six weeks, for a total of six presentations. The goal was to expose the students to the atmosphere of the senior design presentations, preparing them for following year of senior design. The students were also encouraged to speak with the seniors about their projects and any advice that they may have to offer. In April, the junior students were given a Senior Design Capstone Manual. This manual was a new addition to the curriculum with the intent of providing the students with any necessary information for their forthcoming projects. Content in the manual included an overview about the course and grading, a review of the design process, information about academic honesty, budgeting and documentation, and a comprehensive list of campus resources that may be helpful for the students throughout the course of senior design.

Senior design capstone kicked off with a lecture outlining requirements for a successful project. The goal of this was to reiterate the importance of requirements, teamwork and documentation, while motivating the students to perform to their abilities in the course. Each of the teams was also assigned their own graduate teaching assistant. The

graduate teaching assistant served to act as a mentor to the student teams without being intimidating to the students like a professor may be. The teams meet with their respective graduate teaching assistant once a week to provide a project update, or more depending on project health and necessity. The students were also required to submit two deliverables per week: a weekly executive summary outlining project health and progress and a weekly presentation which is presented to the team's advisory board. These deliverables serve to help the team follow a timely trajectory to project completion while improving the students' presentation skills through repeatability. The presentation timeslots also allow for the professor to reiterate previous skills learned to application, offering feedback and extrinsic motivation. Furthermore, the class formed a partnership with the school's Career Management Services. Career Management Services assists students in finding work after graduation by showcasing career opportunities and helping students with professional communication and resume writing. The Career Management Service Office was able to reiterate the importance of the skills that the students were learning throughout the course of senior capstone design and help the students improve upon them. Career Management Services also set up a lecture series with monthly industry speakers. This allowed for the students to learn more about engineering in the "real world" and how the skills that they were learning would translate to their career. As before, the students were required to complete a Preliminary Design Review and a Critical Design Review in December and April, respectively. The end of senior design marked the end of the students' undergraduate educations.

Table 3 outlines the activities implemented through the intervention plan, including which of the three semesters (Design Methodologies, seme-

Table 3. Detailed List of Intervention Plan Activities, Occurrence, and Frequency

Intervention Plan	Explanation	Occurrence	Frequency	Motivation Factor Targeted
Weekly presentations	Presentations are given to the advisory boards. They are approximately twenty minutes in length with improvement feedback from advisory board	Senior design capstone (semester 2&3)	Weekly	Presentation anxiety
Practice sessions with graduate teaching assistant	Presenting in a less formal setting allows for confidence to be built, and corrections to be fixed without the worry of impact on grade	Senior design capstone (semester 2&3)	Weekly (prior to weekly presentation)	Presentation anxiety & Intrinsic Motivation
Weekly executive summaries to advisory board	Formal written summaries presented twenty-four hours in advance of presentation. The summary talks about accomplishment, issues and future work	Senior design capstone (semester 2&3)	Weekly	Self-regulation
Observation	Students are required to sit through at least six of weekly advisory presentations from the senior capstone design students. After six presentations, the students compose a report on their experiences as well as the pros and cons of each presentation they attended	Design Methodologies (semester 1)	Six occasions	Cognition
Learn requirement fundamentals	The students experience multiple case studies on finding and defining requirements	Design Methodologies (semester 1)	Weekly	
Receive a senior design capstone manual	The senior design capstone manual is composed by the professor to serve as a how-to guide to success in senior design capstone. The document includes grading scenarios, required forms and deliverables for each semester	Design Methodologies (semester 1)	Once	
Requirements of success	In partnership with their advisory boards, the students agree on requirements of the project and sign a contract of success that the teammates agree on	Senior design capstone (semester 2&3)	Once	
Professor re-iterates skills used in previous classes apply to senior design capstone	The professor selects multiple skills from precious classes (e.g., Computer aided drafting, graphical analysis, heat transfer) and applies it to real world examples to remind the students of their abilities	Senior design capstone (semester 2&3)	Continuous	Self-efficacy
Partnership with the school's Career Management Services	An external source to reinforce the students do have the proper skills	Senior design capstone (semester 2&3)	Continuous	
Industry speakers	Industry speakers regarding the workplace experience transition from college	Senior design capstone (semester 2&3)	Monthly	

Table 4. Timeline Before Intervention Plan

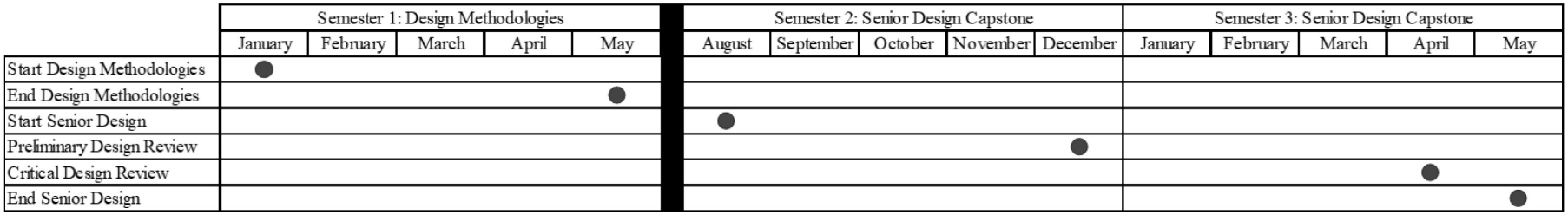
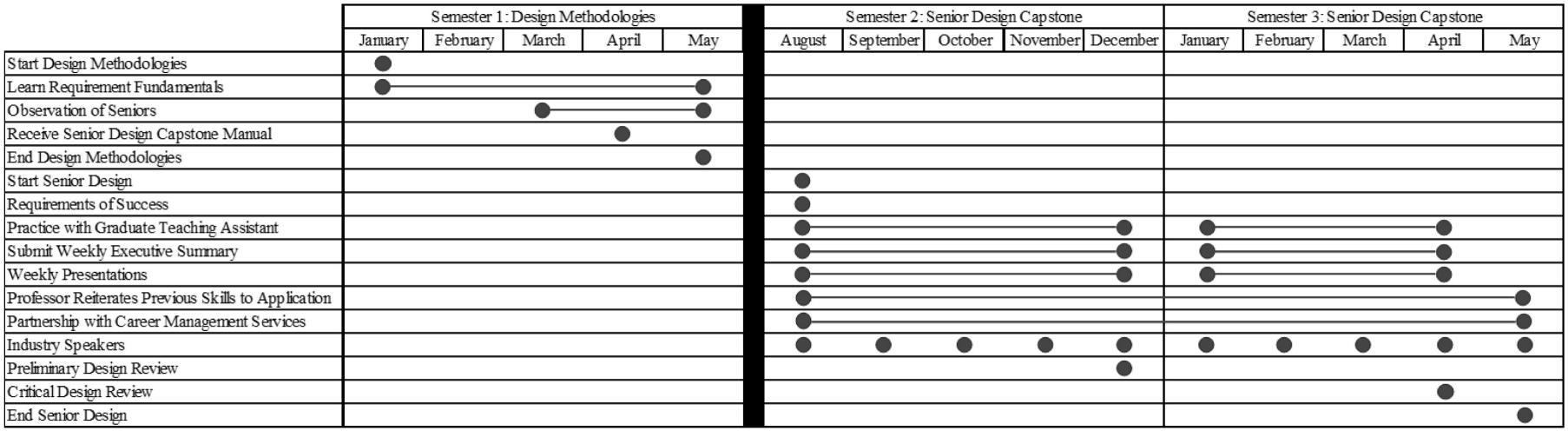


Table 5. Timeline with Intervention Plan in Place



ster 1; or senior design capstone, semesters 2 & 3) the intervention plan takes place during, the frequency of the activity, and the motivation factor that the activity is intended to target. Tables 4 and 5 show the timeline for the three semester sequence before and after the intervention plan was implemented.

4. Research method and instruments

Qualitative and quantitative data was obtained at the beginning of the fall and at the end of the spring semester. For quantitative results, an adaptation of the common MSLQ was disseminated [34]. End of the semester interviews were conducted with the teams to gain qualitative data to support the study. The qualitative data collected here is used to provide reinforcement to any quantitative data findings. While qualitative data will be presented, the scope of this paper focuses on the quantitative data results.

4.1 Quantitative MSLQ

The Motivated Student Learning Questionnaire (MSLQ) quantitatively measures ambition and learning, the two areas of motivation [5]. Ambition is measured with the study of test anxiety, self-efficacy and intrinsic value. Learning is observed with cognitive value and self-regulation [2]. The factors all interconnect with one another forming motivation. One major adaption made was converting test anxiety to presentation anxiety. This study included 43 various questions on senior design capstone activities, including presentations, organization, and education. Sentences within the survey may seem similar; this was done to avoid one question causing an outlier in the results by theoretically testing the same characteristic negatively. The results were then input into data files to run in statistical software. Both cohorts of participants took the survey within the first and last month of the course in their respective years.

4.2 Qualitative interview

To reinforce the findings of the quantitative study, students participated in a practice exit interview after their final presentations to the class. Conducted after the team's design review presentation, the team discussion contained a standard list of questions asked to each cohort. Some examples of questions include "Do you believe this class will enhance your engineering capabilities?" and "Was this class difficult?" Questions were developed from sources including the MSLQ, exit interview experience, and partnership with career management services. The interviews were recorded and transcribed to allow for coding of results. While collecting data, the interviewees were provided open-ended questions and asked to elaborate on their thoughts. While a full coding scheme is not presented in this paper, it was used to corroborate the results of the quantitative analysis.

4.3 Analysis performed

Comparisons between cohorts and the samples within the cohorts were performed. Comparisons included demographics versus motivation, motivation between years, and motivation versus performance. Further, regression analyses, often used in educational research [35], were performed to reveal relationships between motivation and demographic variables.

It is important to note assumptions and possible bias of the analysis. The primary assumption is that the sample size was an ample population of mechanical engineering students and therefore could be considered a statistical representation of seniors in a senior design capstone course [1]. Bias may result from a lack of honesty in the student participants; a participant may have supplied desired answers to follow a group consensus or because they were worried about consequences of negative answers.

5. Results

The study presents multiple t-tests and regression analyses to compare the two cohorts and the demographic groups. The two major divisions within the cohorts were between the international and the domestic students and the male and female student populations. The performance metrics utilized here are team and individual grades. In the tables presented in the results section, highlighted rows indicate the analysis was found to be statistically significant within an $\alpha = 0.10$.

5.1 Control cohort results

The control cohort was the control group for the study. The students participated in senior design capstone from Fall to Spring of the academic years. Table 6 details the differences in motivational factors between the Fall and Spring semester.

The results illustrate the statistical significance identified within all the factors, indicating the course had a significant effect on their motivational

Table 6. Control Cohort Semester Changes

Factor	Fall	Spring	p-value
	$\bar{x} \pm \sigma$	$\bar{x} \pm \sigma$	
Anxiety	3.44 ± 0.33	2.81 ± 0.45	0.019
Self-Efficacy	5.71 ± 0.26	6.04 ± 0.42	0.002
Self-Regulation	4.30 ± 0.22	4.78 ± 0.30	<0.001
Cognitive Value	4.77 ± 0.52	5.51 ± 0.61	<0.001
Intrinsic Value	5.85 ± 0.58	6.13 ± 0.33	0.017

Table 7. Test Cohort Semester Changes

Factor	Fall	Spring	p-value
	$\bar{x} \pm \sigma$	$\bar{x} \pm \sigma$	
Anxiety	3.81 ± 1.52	3.18 ± 1.30	<0.008
Self-Efficacy	4.89 ± 0.55	5.99 ± 0.90	<0.001
Self-Regulation	5.79 ± 0.50	5.12 ± 0.48	<0.001
Cognitive Value	5.11 ± 0.61	6.14 ± 0.74	<0.001
Intrinsic Value	6.17 ± 0.51	6.15 ± 0.51	0.901

factors. All factors, with the exception of presentation anxiety, increased. All five factors revealed a positive significant change in the Likert score values; anxiety decreased, self-efficacy, self-regulation, cognitive and intrinsic value increased.

5.2 Test cohort results

The test cohort contains the students that enrolled in senior design capstone during Year 2. These students were exposed to the Design Methodologies intervention plan. Table 7 details all the factors had a significant statistical change, except for intrinsic value, which did not change.

Anxiety factor decreased approximately one Likert scale point. Similarly, cognitive value increased approximately a whole point. Self-efficacy and self-regulation increased only slightly, but still resulted in p-values below 0.001. The results illustrate the changes among the factors. All the factors besides self-regulation and self-intrinsic value were positively affected. Intrinsic value remained at the same, with a relatively high value of 6.16 on the scale.

5.3 Comparison of cohorts

Examining the factors between the two years led to interesting comparisons in the senior design capstone classes. The visualization of the differences aided in the qualification of the intervention plan. Further, there were marked differences observed as a result of the intervention plan. Whereas there are positive deltas experienced through enrollment in the course alone, participation in the intervention plan yielded higher differences within the semester.

5.3.1 First semester

The changes between the two cohorts Likert values are detailed in Table 8 where rows that are highlighted in Table 8 represent statistically significant data.

The motivational factors changed significantly between the beginning and end of their senior design capstone experience for all of the participants. Self-efficacy and cognitive value showed a statistically significant decrease, while self-regulation and intrinsic value increased. The only factor

Table 8. First Semester Comparisons between Cohorts

Factor	Control Cohort	Test Cohort	p-value
	$\bar{x} \pm \sigma$	$\bar{x} \pm \sigma$	
Anxiety	3.44 ± 1.53	3.81 ± 1.52	0.182
Self-Efficacy	5.71 ± 0.65	4.89 ± 0.55	<0.001
Self-Regulation	4.30 ± 0.47	5.79 ± 0.57	<0.001
Cognitive Value	4.77 ± 0.72	5.11 ± 0.60	0.008
Intrinsic Value	5.85 ± 0.77	6.17 ± 0.51	0.012

Table 9. Second Semester Comparisons between Cohorts

Factor	Control Cohort	Test Cohort	p-value
	$\bar{x} \pm \sigma$	$\bar{x} \pm \sigma$	
Anxiety	2.81 ± 0.58	3.05 ± 1.10	0.39
Self-Efficacy	6.04 ± 0.51	5.99 ± 0.90	0.784
Self-Regulation	4.78 ± 0.55	5.12 ± 0.48	0.004
Cognitive Value	5.51 ± 0.78	4.81 ± 0.54	<0.001
Intrinsic Value	6.14 ± 0.577	6.15 ± 0.74	0.95

that exhibited no significant change between the cohorts was anxiety. It is important to note that the intervention plan started during the Design Methodologies course, which takes place prior to administration of this survey. This may explain the vast differences between the factor scores.

5.3.2 Second semester

During the spring, the students are completing their senior design capstone projects and most are preparing to graduate. As shown in Table 9, most of the factors remain statistically similar between the cohorts. Anxiety is relatively low, self-efficacy is high, and self-regulation and cognitive value are high as well as intrinsic value.

A negative change between cohorts is not necessarily undesirable since the cohorts were two separate samples that started with different values.

5.3.3 Overall change through the year

To observe how well the intervention plan worked, the change between factors was compared for both cohort groups. These changes focused on students who completed both semesters of the survey, so there are no outliers that may skew results. Shown in Fig. 1, the test cohort, the cohort exposed to the intervention plan, had the highest change in anxiety, decreasing the value by almost a whole Likert point.

Self-regulation was also positively affected, improved from the control cohort, which had a negative change. Cognitive value improved slightly more in the test cohort than the control cohort. Intrinsic value, while improved in the control cohort, was unchanged in the test cohort.

5.4 Gender comparison

When isolating the gender demographic, there were

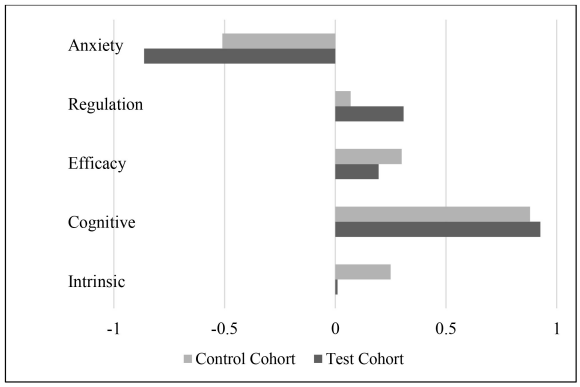


Fig. 1. Overall Changes among Factors between Cohorts.

Table 10. Male versus Female

Factor	Male	Female	p-value
	$\bar{x} \pm \sigma$	$\bar{x} \pm \sigma$	
Anxiety	3.73 ± 1.50	3.22 ± 1.70	0.283
Self-Efficacy	5.15 ± 0.66	5.61 ± 1.00	0.105
Self-Regulation	5.28 ± 0.91	4.78 ± 0.75	0.029
Cognitive Value	4.96 ± 0.65	5.13 ± 0.81	0.446
Intrinsic Value	6.07 ± 0.61	5.89 ± 0.81	0.425

differences that varied from the overall population. The results for all the factors within the control cohort and the test cohort are shown in Table 10.

The populations were combined to see overall comparisons among the demographics in the first semester. The only statistically significant changes were in self-efficacy and intrinsic value, in which both decreased. There appears to be multiple factors that are different between genders, however only self-regulation is statistically significant.

Regression analysis showed a p-value of 0.08 for the change in intrinsic value to females which is within the accepted alpha of 0.10 and can be included for discussion. The plot shows that male students begin with a higher initial intrinsic value. The model of the self-efficacy factor resulted a p-value of 0.00345 which is highly significant. This demonstrates female students possess a higher self-efficacy value.

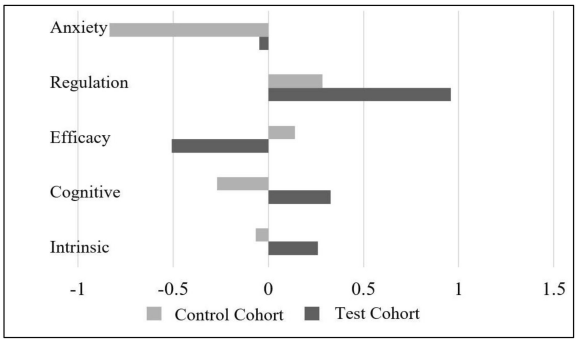


Fig. 2. Overall Changes in the Factors of Male Students.

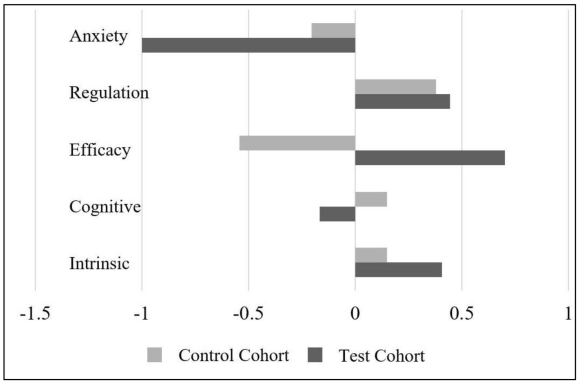


Fig. 3. Overall Changes in the Factors of Female Students.

Table 11. International versus Domestic

Factor	International	Domestic	p-value
	$\bar{x} \pm \sigma$	$\bar{x} \pm \sigma$	
Anxiety	4.28 ± 1.34	3.15 ± 1.42	<0.001
Self-Efficacy	5.08 ± 0.67	5.31 ± 0.67	0.058
Self-Regulation	5.20 ± 0.74	5.23 ± 1.02	0.846
Cognitive Value	4.99 ± 0.75	4.97 ± 0.30	0.877
Intrinsic Value	6.03 ± 0.62	6.06 ± 0.66	0.804

Figures 2 and 3 show the graphical illustration of the changes between the students who participated in both semesters of their respective cohorts.

5.5 Demographic comparison

Significant statistical findings resulted from comparing the domestic and international student populations. Using a t-test comparison and regression model, the findings are shown in Table 11.

The statistically significant change occurred in presentation anxiety and self-efficacy. The student's anxiety had a high significance of p-value < 0.001, while the significance of the self-efficacy was only maintained for discussion at a p-value of 0.058. Higher anxiety levels occurred in the international students. The overall changes in the factors between the international cohorts is represented in Fig. 4.

Anxiety levels decreased immensely by almost 2 points for the test cohort. However the test cohort

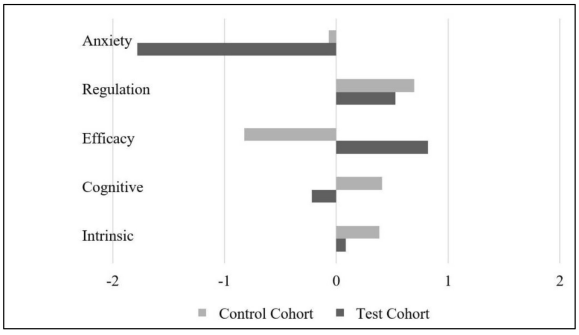


Fig. 4. Overall Changes in Factors of International Students.

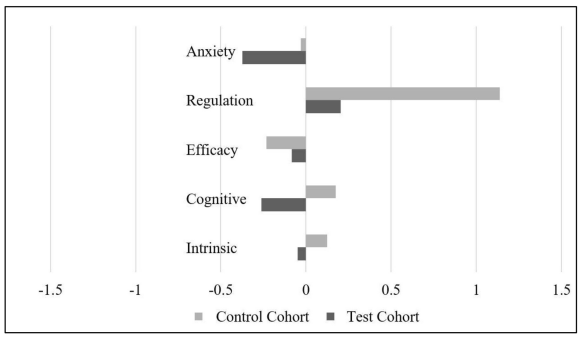


Fig. 5. Overall Changes in Factors of Domestic Students.

had a negative impact in cognitive value and a smaller increase in intrinsic value than the control cohort. Represented in Fig. 5 are the overall changes in the factors between the domestic cohorts.

Anxiety decreased almost a half of a point in the test cohort. Recall that negative anxiety is a positive impact because the goal is to decrease the student's anxiety when presenting. While small, the test cohort had a decrease in cognitive value, intrinsic value, and self-efficacy than the initial control cohort.

5.6 Performance based comparison

Data on individual student performance was the calculated through the score from peer evaluation and the grade given by the advisory board. Figures 6 and 7 show the regression results from plotting grade versus presentation anxiety for the various demographics.

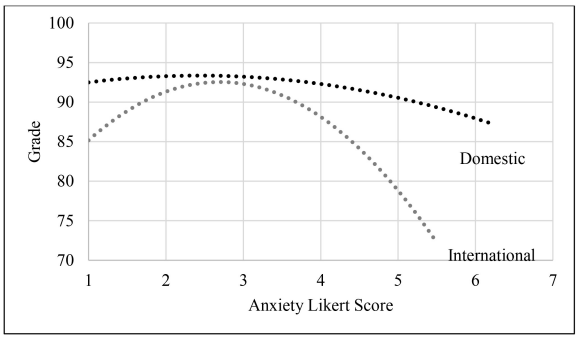


Fig. 6. Comparison of Grade vs. Anxiety for International and Domestic Students of Control Cohort.

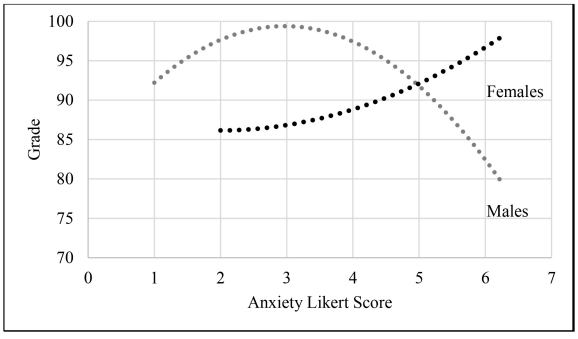


Fig. 7. Comparison of Grade vs. Anxiety for Males and Females of Control Cohort.

Anxiety affected each demographic differently; for males and the general categories of international or domestic student, higher anxiety resulted in a lower grade. For the female students, however, this was opposite; higher anxiety levels resulted in a higher grade. Comparing international students to domestic students, the graph displays that the levels of anxiety presented a higher detriment to the international students than the domestic students.

5.7 Qualitative results

Qualitative data was taken to draw correlation between the results of students' scores and their motivation and outlook on senior design capstone. The majority stated doing well in the class was receiving an "A" or showcasing the project. Almost all of the students indicated wanting to perform well in the class; however, there were a few students that suggested that their grade was unimportant to them as long as they were able to pass the class and graduate. Teams sponsored by industry wanted to impress their sponsors to possibly get a position at the company after graduation. Some students indicated the desire to impress their friends and families as motivation to excel. One female stated that she wanted to show her friends that she could, in fact, be an engineer.

Other statements from students include that the course is 100% indicative of their potential as an engineer. The seniors overall enjoyed the sequence of classes. Most suggested that the process allowed them to work outside their comfort zone, demonstrating that the team-based environment of the class was challenging and enjoyable.

6. Discussion

The study suggests that the student's motivation changes depending on their background. All of the students involved in this intervention plan were senior level students participating in capstone design in the Department of Mechanical and Aerospace Engineering at Florida Institute of Technology. However, the students differed in their gender and origins. These differences resulted in differences in motivation.

6.1 Control cohort results

In the first year of the study, all the factors changed significantly. This is to be expected, as senior design capstone is a new endeavor, and students tend to value it over a traditional class. It is important to note that this class did not have any intervention plan in place. Design Methodologies and senior

design capstone were run as it had been in previous years, with no significant changes.

The seniors presented weekly, so it became more natural to them and their anxiety decreased slightly. Typically by the end of the semester, the students are comfortable with the advisory board and therefore comfortable with presenting in front of them because it is a non-intimidating environment. The students are proud that they have accomplished something and they believe in themselves and their potential, therefore significantly increasing intrinsic value. The student design showcase is a very good intrinsic motivator as well, since the public and school officials congratulate the teams on their hard work and accomplishments. As the students prepare themselves for completing the project they learn new cognitive and self-regulation skills that increase those factors. Since the survey is completed at the completion of senior design, the self-efficacy value is drastically higher; this could be due to the fact that the stress of the class is gone and the students were able to see their efforts pay off.

The initial year displayed that senior design capstone course, alone, does help to improve motivational factors. This allowed for a foundation to build the intervention plan from to make an even greater impact on the motivation level of the engineer.

6.2 Test cohort results

The second year of the study proved to be a test of the intervention plan. The plan was put in place in the Design Methodologies class and continued through the following year. The initial motivation level was actually slightly higher than that of the previous cohort group. One downfall is not knowing if this was due to the Design Methodologies intervention since there was no prequel to the survey. Comparing the change between semesters, the observation can be made that all but intrinsic value were changed with high statistical significance.

Presentation anxiety was decreased greatly over the semester, demonstrated by the p-value. Self-Efficacy was improved greatly with a high significance, most likely due to the students being pleased with themselves and that they had accomplished something that they had previously viewed as a very daunting task. Cognitive value was also highly effected, showing that the students were able to learn to structure themselves and complete the necessary requirements; this was aided by the necessity to display the executive summaries and report what was completed between weekly meetings.

Intrinsic value stayed consistent through the year. The intrinsic value was high for the test cohort in the fall semester, leaving little room for improvement. This high initial value could be due to the increased awareness and understanding of the expectations of senior design, as taught to them in Design Methodologies. Since the intervention plan included the previous seniors presenting to the juniors at instances throughout Design Methodologies, the test cohort were better prepared coming into senior year.

Overall the changes within the semester are positive and show that the intervention plan and senior design capstone together did have a positive impact on the students' motivational factors.

6.3 Comparison between cohorts

The control and the test cohorts were compared between the respective first and second semesters, as well as a total delta between the two cohorts.

6.3.1 First semester

In the first semester, the students are beginning to define the requirements and plan the scope of their project. In this semester, the students demonstrate an increased confidence in their abilities to complete the task, but also an inability to arrange themselves to a larger completion of a goal. This could be contributed to the implementation of the teams in Design Methodologies. The anxiety levels remain about neutral, exhibiting that both cohorts of students are anxious about their performance in the course. The male populations displayed high intrinsic values, indicating that males in the cohorts of this study are confident in their abilities as engineers. The female population showed changes within the self-efficacy and self-regulation factors. There was a significant decrease in the motivation that they have in their ability to succeed; but there was an increase in the success structure to reach an end goal [1]. The international and domestic populations produced similar results, will small positive increases being a possible result of the intervention plan or finding more enjoyment in their project.

6.3.2 Second semester

The second or final semester of senior design capstone is the spring semester. In this semester the students are completing their projects including the manufacturing and testing. They are finalizing documentation and preparing for the senior design showcase, put on by a local engineering company. The surveys are handed out within the same week as showcase signifying the end of the senior design capstone curriculum. When comparing the two years' final semesters, it was interesting to see that most of their factors resulted similarly to one another with the exception of self-regulation and cognitive value.

Self-regulation was higher in the test cohort than

that of the control cohort; this could be due to the fact that the intervention plan had actions set to target that factor specifically. Self-efficacy, as discussed prior, is the belief that one can complete a task. Since more attention was paid to help the teams attain this factor, it allowed the students to reach a higher level. Cognitive value, however, decreased between semesters although it was still on the higher end of the spectrum. This could be due to a variety of reasons which merits deeper investigation.

6.3.3 *Overall change through the year*

The best way to observe the strides of the intervention plan was to see the overall delta of the factors between the students. Since the goal was to observe a change between the two cohorts, the data was filtered to include only students participating in both semesters. The deltas for each cohort were calculated and plotted to reflect the difference in change between cohorts. In total, there were 63 students that completed both surveys in the test cohort and a total of 44 students in the control cohort. This comparison demonstrated the positive change students experienced throughout the year. Note that a negative change in anxiety is positive since it is a negatively coded item.

Considering the graph in Fig. 1, the anxiety, regulation and cognitive value were positively affected a greater amount in the test cohort. Anxiety decreased nearly twofold which indicates that the changes made by the intervention plan were a success. Regulation went from being negative in the control cohort to positive in the test cohort, indicating that the students are confident in their ability to get tasks done. Intrinsic Value stayed the same in the test cohort. The reason behind the intrinsic value remaining constant could be due to the fact that the test cohort came into senior design capstone with an already high intrinsic value, and success can be found that it wasn't negatively affected.

6.4 *Gender comparisons*

Combining all student responses displayed an overall result where males exhibit higher anxiety and females have a higher self-worth, resulting in a higher intrinsic value. Males have a higher positive change in terms of their cognitive value. This could be due to the fact that females are still new and underrepresented in the field of engineering, therefore lacking some confidence in their abilities to perform as well as males in the field. This leads to doubts in their ability to plan a set of actions to find success [1, 36, 37].

6.5 *Demographic comparison*

The findings of highest significance occurred within the population of international versus domestic students. It is found with high confidence that international students have high presentation anxiety during the senior design capstone course [16]. This anxiety is likely due to the fact that most international students do not have previous exposure to a presentation realm; a presentation tends to be an extraneous concept to them which causes anxiety [36]. Additionally, many international students believed that their presentation skills were poor because English was not their first language. During the qualitative interviews, most students agreed that they were anxiety prone during presentations as they wanted to show they were performing well.

Also shown with a high significance within international students was the correlation between their peer review statistics and the answers on the self-regulation portion of the survey. Many students stated they were used to the traditional course structure featuring homework and exams, while this course did not follow this structure. Senior design capstone involves designing, analyzing, presenting, and following a product through to completion, a concept that was foreign to them. As a result, many students revealed they believed that they struggled to perform to their potential. The findings regarding self-efficacy also echoed these results. International students naturally thought their capabilities were limited due to their foreign background.

Differences in intrinsic motivation were realized between international and domestic students. Although this change was significant to an alpha of 0.10, domestic students displayed greater intrinsic motivation than their international counterparts. Most domestic students tend to have a greater understanding of the structure of a capstone course, however international students struggle to adapt to this format [16].

6.6 *Performance considerations*

The performance factor results of the survey proved to be very interesting. One would expect higher anxiety to decrease the student's grade. However, the female students displayed opposite results to this: more anxiety improved the student's grade. Although this displays an improved performance, it was not in a positive manner. The goal of the study was to use positive aspects, such as confidence, to improve performance, not the negative of anxiety. It can still be stated with great confidence that students with higher grades tended to exhibit more anxiety. The demographics of males, international and

domestic, reflect this. International student's anxiety resulted in an extreme impact on their grades. Causation may stem from having a different background as their domestic counterparts, or an increased nervousness given that English is not their native language.

6.7 Qualitative analysis

The qualitative results were used for insight to the students' quantitative grades. While the majority of students believed that success in the course was receiving an "A", some of the industry sponsored teams' goals were to impress their sponsoring company to earn a job post-graduation. Some students were also more concerned with seeing the project through to a success completion rather than their final quantitative grade in the course. Most of the students were satisfied with their ability to apply the theoretical knowledge gained throughout their undergraduate tenure to a real-world engineering scenario.

Students ranked the class as the most important class in their collegiate career despite also finding it to be harder than previous classes. One student stated that this class should be offered earlier in the undergraduate program, because if he had known engineering was this hard, he would not have majored in it.

6.8 Limitations of the study

This study should be viewed as a sample of the motivation of a senior level student in mechanical engineering enrolled in a senior design capstone course. The study lacks the mandatory longitudinal comparisons to understand the difference in motivation of various students throughout various years, cohorts, or project types. There was also not a survey administered to the students of the two cohorts before taking Design Methodologies, which serves as preparation for senior design capstone. Under the intervention plan, the Design Methodologies course was altered to provide the junior level students with a better understanding of the senior design process, through methods such as having the control cohort senior project teams come to present to the junior level students in the test cohort. This increased exposure could result in some of the higher motivation levels entering senior design than the control cohort had exhibited. The ability to compare the control and test cohorts before taking part in Design Methodologies would allow for better comparisons to be drawn between the two cohorts, and determine the extent of the motivation improvements caused by the intervention plan with regard to the first semester surveys.

The sample size of this study was limited by the graduating class size. Future studies could serve to validate this snapshot study and expose new statistical information unable to be found within this sample group.

7. Conclusions

The study compares results between cohorts and demographics of the senior design capstone classes at Florida Institute of Technology. The study demonstrates how motivation is a dynamic quality and changes between cohorts, as well as between demographics. The MSLQ survey was used in this study to analyze the motivation of senior design capstone students in the mechanical and aerospace engineering department.

At the start of the course, anxiety played a large role on the course performance, especially when isolating the international students. While anxiety decreased the performance of the male student, this proved opposite for female students; female students tended to perform better when anxious. While high student performance is desired, the author desires to use positive factors to improve student performance instead of negative factors.

Between the two cohorts, the test cohort came into the senior design capstone course with higher anxiety; this was possibly caused by the intimidation from observing senior design teams' accomplishments the previous semester/school year. Overall, there was still a greater change in the anxiety factor in the test cohort. All factors improved with a greater delta except for intrinsic value. The test cohort entered senior design capstone with an extremely high internal confidence.

The intervention plan did make a positive impact on the student's factors. The plan greatly helped the international student population. More importantly, the intervention plan reinforced doing well for positive factors instead of negative ones.

References

1. A. Bessette, B. Morkos and S. Sangelkar, Improving Senior Capstone Design Student Performance through Integration of Presentation Intervention Plan, in *ASME 2015 International Design Engineering Technical Conference*, pp. DETC2015–47604, 2015.
2. B. A. Hons and B. Ed, *An Investigation Of Gifted Students' Intrinsic Motivation And Classroom Productivity* by Leanne McGrimmond Thesis Submitted In Partial Fulfilment of the Requirements For The Degree of Master of Arts In the Faculty of Education © Leanne McGrimmond 2009 SI. 2009.
3. E. Deci and R. M. Ryan, Self-determination theory and the facilitioan of intrinsic motivation, self development and well being, *Psychologist, American*, **55**, pp. 68–78, 200AD.
4. B. Galand, B. Raucent and M. Frenay, Engineering students "self-regulation" study strategies, and motivational believes in traditional and problem-based curricula, *International Journal of Engineering Education*, **26**(3), pp. 523–534, 2010.
5. P. R. Pintrich, D. A. F. Smith, T. Garcia and W. J.

Mckeachie, *A Manual for the Use of the Motivated Strategies for Learning Questionaire (MSLQ)*, 1991.
6. A. Bandura, *Self-efficacy: The exercise of control*, New York: Freeman, 1997.
7. S. Jaschik, Well-prepared in their own eyes, *Inside Higher Education*, pp. 1–13, 2015.
8. S. A. Helmi, K. Mohd-Yusof and F. A. Phang, Enhancement of Team-based Problem Solving Skills in Engineering Students through Cooperative Problem-based Learning, *International Journal of Engineering Education*, **32**(6), 2016.
9. E. A. Linnenbrink and P. R. Pintrich, Motivation as an Enabler for Academic Success, **31**(3), pp. 313–327, 2002.
10. P. R. Pintrich and D. H. Schunk, *Motivation in education: Theory, research and applications*, 2nd ed. Upper Saddle, NJ: Prentice-Hall, Inc., 2002.
11. H. T. Roman, Reengineering Education: A Change is Needed in U.S. Engineering Education, *IEEE Power & Energy Magazine*, no. June, pp. 85–88, 2004.
12. A. Gero, Y. Stav and N. Yamin, Increasing Motivation of Engineering Students: Combining 'Real World' Examples in a Basic Electric Circuits Course, *International Journal of Engineering Education*, **32**(6), 2016.
13. E. Schmitt, E. Kames and B. Morkos, Importance of Incorporating Designer Empathy in Senior Capstone Design Courses, *Am. Soc. Eng. Educ.*, 2016.
14. A. J. Dutson, R. H. Todd, S. P. Magleby and C. D. Sorensen, A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses, *Journal of Engineering Education*, **86**, no. January, pp. 17–28, 1997.
15. R. E. Gander, J. E. Salt and G. J. Huff, An electrical engineering design course sequence using a top-down design methodology, *IEEE Transactions on Education*, **37**(1), pp. 30–35, 1994.
16. A. Bessette, V. Okafor and B. Morkos, Correlating Student Motivation To Course Performance in Capstone Design, in *International Design Engineering Technical Conference*, pp. 1–12, 2014.
17. S. Sheppard, S. Gilmartin, H. L. Chen, G. Lichtenstein, Ö. Eris and M. Lande, Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES) TR-10-01, *Engineering*, no. September, 2010.
18. D. Knight, L. Carlson and J. Sullivan, Improving engineering student retention through hands on, team based, first year design projects, in *Annual International Conference on Research in Engineering Education*, 2007.
19. E. W. Banios, *Teaching Engineering Practices*, pp. 161–168, 1991.
20. K. A. Debalek and J. Roth, Chemical Process Design; An integrated Teaching Approach, *Chemical Engineering Education*, **16**(2), pp. 72–75, 1982.
21. H. A. Etlinger, A retrospective on an early software projects course, *ACM SIGCSE Bulletin*, **22**(1), pp. 72–77, Feb. 1990.
22. H. Silla, Development of the Design Laboratory, *Chemical Engineering Education*, **20**(1), pp. 44–47, 1986.
23. G. Jakubowski and R. Sechler, SAE Student Design Competion as Capstone Courses, in *Advances in Capstone Education*.
24. K. S. Ibwe, E. A. Kalinga, N. H. Mvungi, H. Tenhunen and V. Taajamaa, The Impact of Industry Participation on Challenge Based Learning, *International Journal of Engineering Education*, **34**(1), 2018.
25. L. Harrisberger, Experiemential Learning in Engineering Education, *American Society for Engineering Education*, 1976.
26. S. P. Magleby, C. D. Sorensen and R. H. Todd, Integrated product and process design: a capstone course inmechanical and manufacturing engineering, *Proceedings Frontiers in Education Twenty-First Annual Conference. Engineering Education in a New World Order*, pp. 469–474, 1991.
27. B. Linnerud and G. Mocko, Factors That Effect Motivation And Performance On Innovative Design Projects, in *International Design Engineering Technical Conference*, pp. 1–8, 2013.
28. N. Delson, Increasing Team Motivation in Engineering Design Courses, *International Journal of Engineering Education*, **17**(4/5), pp. 359–366, 2001.
29. C. J. Ferrante, S. Green and W. R. Forster, Getting More out of Team Projects; Incentivivizing Leadership to Enhance Performance, *Journal of Management Education*, **30**(6), pp. 788–797, 2006.
30. T. J. Allen and R. Katz, Age, Education and Technical Ladder, *IEEE Transactions on Engineering Management*, **39**(3), pp. 237–245, 1992.
31. J. Rotter, Generalized expectancies for internal versus external control of reinforcement, *Psychological Review*, **80**, pp. 1–28, 1966.
32. E. Crawley, J. Malmqvist, S. Ostlund and D. Brodeur, *Rethinking Engineering Education: The CDIO Approach*. 2007.
33. P. M. Efixl, Motivation as an Enabler for Student Success, 2002.
34. J. J. Ramirez-Echeverry, A. Garcia-Carrillo and F. A. Olarte Dussan, Adaptation and Validation of the Motivated Strategies for Learning Questionnaire—MSLQ—in Engineering Students in Colombia, **32**(4), pp. 1–14, 2016.
35. S. Teegavarapu, J. D. Summers and G. Mocko, Case study method for design research, in *ASME Design Engineering Technical Conference*, 2008.
36. E. Kames, D. Shah and B. Morkos, A Longitudinal Study Exploring Motivation Factors in Cornerstone and Capstone Design Courses A Longitudinal Study Exploring Motivation Factors in Cornerstone and Capstone Design Courses Abstract, *Am. Soc. Eng. Educ.*, 2018.
37. S. Haag, N. Hubele, A. Garcia and K. McBeath, Engineering undergraduate attrition and contributing factors, *International Journal of Engineering Education*, **23**, pp. 929–940, 2007.

Elisabeth Kames is currently pursuing her PhD in Mechanical Engineering at Florida Institute of Technology with a focus in design education. She graduated cum laude with her Bachelor of Science degree in Mechanical Engineering in May 2015. She also graduated with her Master of Science degree in Mechanical Engineering with a concentration in Dynamic Systems-Robotics and Controls in December 2016. She is part of the STRIDE (SysTems Research on Intelligent Design and Engineering) Lab. Her research focuses on the impact of motivation on performance and persistence in mechanical engineering design courses under the guidance of Dr. Beshoy Morkos. She also serves as a graduate student advisor to senior design teams within the mechanical engineering department. Elisabeth is a member of ASME, ASEE, Tau Beta Pi Engineering Honor Society and Pi Tau Sigma International Mechanical Engineering Honor Society.

Beshoy Morkos is an associate professor in the Department of Mechanical and Civil Engineering at Florida Institute of Technology where he directs the STRIDE Lab (SysTems Research on Intelligent Design and Engineering). His engineering design research focuses on developing computational representation and reasoning support for managing complex system design. The goal of Dr. Morkos' research is to fundamentally reframe our understanding and utilization of system representations and computational reasoning capabilities to support the development of system models which help engineers and project planners intelligently make informed decisions at earlier stages of engineering design. On the

engineering education front, Dr. Morkos' research explores means to integrate innovation and entrepreneurship in engineering education through entrepreneurially-minded learning, improve persistence in engineering, address challenges in senior design education, and promote engineering education in international teams and settings. Dr. Morkos' research is supported by government (National Science Foundation (NSF), Office of Naval Research (ONR), United States Navy, NASA Jet Propulsion Laboratory (JPL)) and industry (Lockheed Martin, Sun Nuclear, Northrop Grumman, Rockwell Collins, PTC). Dr. Morkos received his PhD from Clemson University in the Clemson Engineering Design and Applications Research (CEDAR) lab under Dr. Joshua Summers. In 2014, he was awarded the ASME CIE Dissertation of the year award for his doctoral research. Dr. Morkos was a postdoctoral researcher in the Department of Engineering & Science Education at Clemson University performing NSF funded research on engineering student motivation and its effects on persistence and the use of advanced technology in engineering classroom environments. Dr. Morkos' research thrust include: design automation, design representations, computational reasoning, systems modeling, engineering education, design education, collaborative design, and data/knowledge management.

Amanda Bessette is a Systems Engineer for the FIRST Robotics Competition. She graduated with her Master's degree in Mechanical Engineering from Florida Institute of Technology in 2015. Her research is focused on the impact of motivation on performance in senior design capstone courses. Amanda has always been passionate about promoting STEM and Engineering Education, as well as increasing the involvement of underrepresented minorities in STEM disciplines.