Impact of Educators Changing Student Motivation: A Study of Transient Factor Correlation and Orthogonality

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ABSTRACT

Previous research has indicated the importance of student motivation to persistence in engineering and course performance in design-based courses. This particularly is true for senior capstone design, where students focus their attention on a single design prompt for up to three consecutive semesters. We hypothesized that students possess a natural inclination towards types of capstone projects, and their choice of a project may impact their motivation levels throughout their experience in the design course, which ultimately will impact their performance. While educators have made attempts to influence specific motivational factors to improve student performance, the interdependency of motivation factors as they change is unknown. This paper examines the correlation and the interdependency between student motivation factors. Using the MSLQ questionnaire by Pintrich, we examine five factors of motivation: cognition, self-regulation, intrinsic value, test anxiety, and self-efficacy. In this study, two cohorts of senior capstone design students completed the Motivated Strategies for Learning Questionnaire (MSLQ) to self-evaluate their motivation on a 7-point Likert scale at two instances (beginning and end of senior capstone design course). The study is performed through a two-fold analysis: Covariance/Correlations and Principal Component Analysis.

A principal component analysis indicated that each of the factors uniformly captured the variation in the data – an indication of a well-designed instrument. However, the results of the study also indicated that motivation factors do possess correlation with one another (except for anxiety, which displayed no correlation with two factors and low correlation with the remaining factors). The results indicate that changes to one factor by an educator may unintentionally make changes to other factors that may have an unanticipated net effect on their motivational level.

1. INTRODUCTION

The demand for skilled engineers is increasing with the growing number of technological advances, industries, and bolstering the economy [1]. The exponential rise in demand for innovation, to meet the growing needs of the fourth industrial revolution is unlike anything the United States has experienced in the past [2]. Educators face new challenges in preparing the new generation of engineers with technical skills and overall readiness for the new industrial revolution (Industry 4.0). Universities have experienced a 54% increase in student enrollment from 2008 to

2017 across engineering disciplines [3]. Over 30,000 degrees were awarded to undergraduate mechanical engineers in 2017 in the United States alone [3], the highest among all engineering disciplines. Understanding the factors contributing to this high enrollment rate can help educators and policymakers improve the engineering curriculum and other programs across campus. however high enrollment doesn't ensure higher graduates. Engineering programs across the country continue facing the everlasting problem of student retention [4]. This paper is a part of an extended study on persistence in engineering and student motivation.

Motivation is considered here as it is a tenant of STEM education research [5] and serves as a foundation for understanding student success [6] and persistence [7]. Further, motivation has impacted how problem [8] and project [9] based learning is implemented. Research in engineering education has highlighted the interconnectedness of problem-based and project-based learning approaches [10,11]. However, the recipe for student development is beyond that of "hard skills", for example, technical knowledge and project experiences. Universities and colleges are starting initiatives to promote student development by cultivating a student's "hard skills" and "soft skills" – such as cognitive knowledge [12,13] and teamwork [13,14], respectively. Ultimately, educators want to ensure students leave with all the necessary skills to succeed in the workplace.

Senior capstone design courses provide an opportunity for undergraduate engineering students to participate in project-based learning, a unique learning experience requiring hard skills and soft skills [15]. Research has identified the importance of senior capstone design on student success entering an industry, rendering it a critical course in the engineering curriculum [16,17]. In prior research, motivation was observed to be one of the constructs contributing to student's overall success as measured by factors such as project performance, peer evaluations, and course performance [18,19].

1.1 Prior Research

A recent study in student retention in engineering [4] suggests retention rates between 40-60%. It becomes more crucial than ever to study how students perform and behave in classroom environments. A deeper understanding of student behavior, motivation, and interest are necessary before implementing changes in the curriculum.

Student motivation has proven to be an efficient and reliable precursor to measure student success and persistence in STEM. Motivation is regarded as one of the most influential aspects of

success [20], alongside sound technical knowledge in engineering. Across all disciplines, educators and practitioners have noted the importance of student motivation in producing an engaging learning environment [21]. The impact of student motivation is studied for decades and researchers have suggested various intervention plans to improve learning and performance [22,23]. As an example, self-efficacy and intrinsic motivation are improved through the use of modules, assignments, makerspace cultures, interdisciplinary projects, and experiences in design courses – particularly senior capstone design courses [24]. Design courses are critical and important in undergraduate mechanical engineering programs as students have often cited entered mechanical engineering programs for their passion toward designing and building [25]. The capstone design course is one such course that offers a unique advantage to study student motivation as this course requires students to amalgamate and implement the collective learning from the program. Capstone course is regarded as a provider of high impact practice and assessment [26,27].

Capstone Design Course at the private school studied here offers two types of projects, industry-sponsored projects, and non-industry sponsored projects. Non-industry sponsored projects include, but are not limited to: competition projects such as SAE Formula or Mini Baja car; humanitarian projects that revolve around providing low-cost solutions to third world countries; or university-sponsored projects, such as the design of a smart football sled for the football team.

The study presented in this paper is a continuation of research examining student motivation in senior capstone design courses. In our previous studies [28], we hypothesized that students possess a natural inclination towards one particular type of project, and choice of the project may impact their motivation levels throughout their experience in the design course. Student motivation was measured through the use of the Motivated Strategies for Learning Questionnaire (MSLQ). Researchers administered the survey at the beginning of the two-semester senior capstone design course and at the end of the course, to measure changes in motivation levels.

The statistical analysis results indicated that, despite reporting a lower motivation score among industry project teams compared to their non-industry project counterparts, they converged to the same motivation score by the end of the course. Table 1 details previous findings of motivation among teams in the senior capstone design course. It is observed that the industry teams scored low on cognition, self-regulation, and presentation anxiety.

Table 1: Mean and Standard Deviation results

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

The MSLQ survey used in the previous study was an adapted version of Pintrich's MSLQ consisting of only five factors of motivation; cognition, intrinsic value, self-regulation, presentation anxiety, and self-efficacy. This is abbreviated compared to the original MSLQ designed by Pintrich and his team which measured a total of fifteen factors of motivation. While this approach is designed to target factors that are illustrated by Pintrich to influence the success of students in STEM fields, it is also important to understand and identify possible interdependency of the five factors in the adapted version.

In this paper, we seek to study the dependency of earlier listed motivation factors to establish understanding at a finer resolution –to the individual factors examined. To do so, we examine the orthogonality of the motivation factors to identify how changing one motivation factor can propagate to other factors, therefore impacting net student motivation.

With the help of this quantitative analysis approach, we want to equip the readers with an understanding of factor relationships and net motivation outcomes. This study explores the impact of change in motivation factors and its overall outcome on student motivation This assists in establishing a model that can determine the effects of variation from one factor to another, positive and negative. If classroom modules/experiences are designed to increase one factor of motivation, this study provides evidence of the resulting impact on other motivation factors. This study contributes to two major areas of border impacts: (1) impact on education practice, and (2) impact on education research.

Studying the attributes and factors affecting motivation; acquiring knowledge of the relationship between each motivation factor is important. Their nature of relationship and direction can assist educators in understanding the working of motivation factors and thus improving motivation through classroom activities and experiences. Example: does high self-efficacy lead to higher intrinsic motivation? Such questions remain unanswered if the motivation factor relationships are not well understood.

This study provides groundwork in instrument development based on motivation and other frameworks (such as identity, which has an overlap with motivation [29]). Relationship and orthogonality of factors are important when generating new instruments and computational models to measure and analyze student success.

The goal of this paper is to correlate motivation factors and establish the dependency of factors to each other. In doing so, we formulate a model to be used by instructors and educators in enhancing classroom learning environment. This assists educators with insights on student motivation in the design course and how this could impact their overall experience in engineering and performance. With this study, we want to answer two research questions (RQ), as presented in Table 2.

Table 2: Research Questions

Research Questions	Objective
RQ1. Does a correlation exist between motivation factors?	The objective of this research question is to determine when measuring student motivation, if there are factors that relate to one another or if a change in one factor may influence another factor.
RQ2. Are the motivation factors orthogonal?	In addressing the first research question, the objective of this question is to determine the level of relationship between factors if they are nonorthogonal

2. BACKGROUND

The overall objective of the research questions is to understand how other factors may influence the overall motivation outcome. The previous research performed indicated motivation was significant in predicting student success in design projects and their selection of the said project.

Student Motivation

The goal of senior capstone design courses is to prepare students to enter industry or graduate school upon completion of the yearlong design course. Students, when given a choice of project type for their senior year, incline towards one over the other, which we believe is rooted in their motivation. Pintrich emphasized the importance of motivation in education research [30]. This Latin verb "movere", which means to move, laid the foundation for various motivation theories and to study what makes one move towards a goal [30,31]. Several factors combine to make motivation into a single, robust, measurable entity. We selected five factors of motivation that are commonly used in measuring student motivation in STEM courses. These five factors are

measured through the use of an abbreviated form of Pintrich's MSLQ survey [32]. The MSLQ requires students to self-evaluate their motivation levels on a Likert scale from "not true to me" to "very true to me". The five factors of motivation examined are:

- Cognitive value
- Intrinsic Value
- Self-efficacy
- Self-regulation
- Presentation anxiety

Cognition is coined to be an individual's processing ability of all the information one receives and using it towards a particular task [33]. This can range from problem-solving to idea generation and critical thinking [33], which are some of the salient attributes of a successful engineer. Cognition and metacognition are used in various branches of science to study the functioning of student behavior and performance.

Intrinsic value is defined as an individual's desire to learn and adapt new skills or activities out of curiosity [32,34]. Typically, senior capstone design is a novel format of course work for undergraduate students, it does not replicate the classroom setting and exam format expected in a conventional university lecture hall. Thus, it is important to measure student's intrinsic value in an unfamiliar environment.

Self-efficacy in cognition theory is defined as the characteristics possessed by any individual which assist one in achieving goals by performing actions and tasks [35,36]. Some of the attributes of self-efficacy are experiences, achievements, and peer pressure [37].

Self-regulation is the individual trait of keeping up with required course work and tasks in an organized manner [32]. It varies from person to person and thus it becomes important to study one's motivation level at a particular instant.

Presentation anxiety is defined as the anxiety/nervousness a student experiences when in a presentation environment [32]. It could be studied in a classroom or a formal setting.

Studies in higher education have explained that a student's persistence depends on their sense of belonging [38–40]. Motivation to succeed and having a sense of possible achievement and failure is something every researcher has tried to study and examine with different fields of education. These personality traits transform the work environment on graduation and thus it is

more than important to create awareness of student's experiences in their crucial years of undergraduate studies.

Senior Capstone Design

Senior capstone design course provides a unique blend of problem-based and project-based learning experience in undergraduate engineering programs. Senior capstone design is a mandatory year-long course in many undergraduate engineering colleges across the United States of America. Some of the important elements of the senior capstone design course include solving open-ended problems, real industry problems [41], fabrication, product design, and budgeting. Senior design projects can also be multidisciplinary, with topics ranging from bio-med to aerospace, thus preparing students to work and collaborate across various disciplines of engineering. This approach and experience can be a precursor before entering the industry where they work in teams with different technical and non-technical backgrounds. However, there was a stigma associated in the late '90s with a level of preparedness of graduates entering the industry [16]. There is an ongoing effort to increase the efficiency of the curriculum and provide the most effective and realistic experiences to senior capstone design students before they face real-world industry problems. This paper progresses at contributing to the same goal by providing deeper insight into student motivation and the factors that affect their overall experience in this important capstone year.

Senior capstone design course at a private university on the east coast is divided into two major phases;

- Problem definition and designing,
- Fabrication and performance.

There are two major types of projects offered in the senior year; industry-sponsored and non-industry sponsored. Students choose either one at the end of junior year, in preparation for senior capstone design. This occurs in the student's 1-credit mandatory Design Methodologies class before entering senior design. This course serves as a precursor to the senior capstone design course. The major learning experiences students receive in the design methodologies class are concept generation, planning, and utilization of various design tool [42]. Their choices are based on various factors including future goals, background, interest, and many more. Student teams range from five to twenty students per team. Larger teams are further divided into smaller teams to work on one specific problem/part.

2.1.1.Industry-Sponsored Projects

Industry-sponsored projects typically have a defined problem statement for students at the beginning of the fall semester. These problem statements could be a challenge currently faced by the company. It can also be a design approach they wish to approach in the future. Industry sponsors the project under collaborative guidance from an expert from the company and faculty of the capstone course. Students report bi-weekly to the industry client with a progress presentation. Students working on industry projects are exposed to industry like working environments, including a list of requirements, strict deadlines, and budget. Students get firsthand experience of the real industry problem. Industry projects are further divided into government-funded and privately funded projects. Some of the industry clients at this university are NASA JPL, Harris Corporation, Northrop Grumman, Google, and many more [5]. Studies have shown that such firsthand industry experience provides a good foundation for future careers

2.1.2.Non-Industry Projects

Non-Industry projects are further divided into competition and humanitarian projects. Competition teams are larger in size, ranging from 9 to 15 students per team. Some of competition teams are Formula SAE, Drag car, and more. Competition teams either redesign a car or work on a new assigned car requirement. Competition cars have to work under strict competition requirements. These teams later compete at a national level racing competition. Teams are further split into smaller teams working on different components. Conversely, humanitarian teams are smaller size teams. Students have reported choosing humanitarian projects for their altruistic inclination [25]. Humanitarian projects typically have open-ended problem statements. Students have the freedom to generate their problem statements with guidance from Graduate Students Assistants (GSAs) and instructors. They are guided to generate requirements that align with the senior design project criteria under university guidelines but are also feasible within the time and budget constraints. These problem statements usually target sustainability problems faced in developing countries, with topics ranging from sanitation to agriculture.

Motivation to compete has proven to provide an enhanced learning experience [43]. With this approach, the university facilitates a design showcase at the end of the academic year; the best team based on various judging criteria is awarded the best design project of the year.

3. RESEARCH METHOD

In this study, we use Pintrich's MSLQ Survey Instrument [32] to measure five factors of motivation; cognitive value, intrinsic value, self-efficacy, self-regulation, and presentation

anxiety. We used an adapted version of the MSLQ survey that rephrases a terms regarding anxiety terms. Anxiety is changed to presentation anxiety as we measure motivation only in senior capstone design courses where presentation frequency is higher. This adapted version does not interfere with the reliability of the instrument as it contextualizes the instrument toward senior design. This instrument uses a 7-point Likert scale, where students self-evaluate their motivation levels. Students participate in the motivation survey twice a year; at the beginning of the fall semester and the end of the spring semester of senior capstone design. The MSLQ survey consists of 43 questions targeting the five factors of motivation. Table 3 details the number of questions targeting each factor of motivation in the MSLQ Survey. The adapted MSLQ survey utilized in the study is presented in Appendix A.

Table 3: Motivation Factors

Motivation Factors	No. of Survey Items
Cognitive Value	12
Intrinsic Value	9
Self-Efficacy	9
Self-Regulation	9
Presentation Anxiety	4

Study Subjects and Data Collection

Study subjects are students of the senior capstone design course. Two cohorts of senior design students participated in this survey. 187 students and 179 students from Cohort A and Cohort B, respectively. Cohort A and Cohort B indicates the class of 2017 and class of 2018 of senior capstone design course respectively. The cohorts are further divided into fall semester survey responses, and spring semester responses. The cohorts are divided per semester, and not team types. Thus, the data is analyzed as fall and spring semesters. Both the cohorts have the same instructors. The instructor for the senior capstone design course oversees both project types, industry and non-industry. The student cohorts are amalgamated for analysis in this paper, and team differences have not been considered for this paper. Previous research work by the authors of this paper highlights differences among team experience and projects [25], however the differences have not been accounted for statistical analysis of this paper. As the survey was optional, not every student participated from the senior capstone design teams. The MSLQ survey was conducted in a classroom setting where students were asked to participate before their weekly presentation. No incentive or course grade allocation was provided for student participation.

Data Analysis

To address the research questions in this paper, researchers allocate individual responses under the five factors of motivations. The average answer for each factor is calculated for every participant. A covariance and correlation analysis is performed to examine the dependency of motivation factors. The covariance analysis determines the existence of a relationship between factors. It is performed by developing a square matrix where $C_{i,j}=\sigma(x_i,x_j)$, and $C \in R^{fxf}$ for all factors f. This analysis serves as a precursor for the correlation matrix. Since a covariance is unstandardized (concerning standard deviation) of correlation, correlation analysis in this study determines the strength of the relationship between each factor. Confirmatory factor analysis is conducted to allow assessment of the factors. Principal component analysis assists in finding the dependency of factors. Orthogonal rotation is used to maximize the variation to determine the dependency of the factors, however other rotations (maximum likelihood and oblique) are considered.

4. RESULTS

The study discovers covariance and correlation between motivation factors namely: cognition, intrinsic value, self-efficacy, self-regulation, and presentation anxiety. Students of senior capstone design self-evaluated themselves on a 7-point Likert scale on an adapted version of the MSLQ survey. The previous study aimed to find the motivation levels at two instances in the senior capstone design course: the beginning of the fall semester and end of the spring semester. This study further examines the correlation between the five factors, positive and negative, to understand how changes to one factor may influence others. The findings suggest the strength of the relationship between each factor. Each factor is treated as an individual vector during a principal component analysis.

Fall Semester Findings

The average responses for each factor are considered for calculating covariance and correlation with the remaining factors. Table 4 illustrates the covariance between each motivation factor. Covariance analysis demonstrates the presence of a relation between two factors and the direction of that relationship. For example, it is observed that intrinsic value and presentation anxiety are inversely correlated (*cov* = -0.078). Likewise, self-efficacy and presentation anxiety are inversely correlated (*cov* = -0.103).

Table 4: Covariance Results for Fall semesters of Both Cohorts

	Cognitive Value	Self Regulation	Presentation Anxiety	Intrinsic Value	Self Efficacy
Cognition	0.500				
Self-regulation	0.303	0.434			
Presentation Anxiety	0.295	0.397	2.387		
Intrinsic Value	0.262	0.123	-0.078	0.452	
Self-efficacy	0.236	0.119	-0.103	0.324	0.469

Table 5 shows the result of the correlational analysis. To indicate a linear correlation between the factors, a Pearson correlation coefficient with a value of -1 to +1 is used to understand the strength of correlation among the components.

Table 5: Correlation Results for Fall semesters of Both Cohorts

	Cognition Value	Self Regulation	Presentation Anxiety	Intrinsic Value	Self Efficacy
Cognition	1				
Self-regulation	0.651	1			
Presentation Anxiety	0.270	0.390	1		
Intrinsic Value	0.551	0.279	-0.075	1	
Self-efficacy	0.488	0.265	-0.098	0.703	1

A correlation analysis is conducted to measure the strength of the relation identified through a covariance analysis. The correlation value close to 1, indicates the strength of positive correlation and the direction of the relationship. As shown in the results in Table 5, self-regulation and cognitive value ($r = 0.651$), and intrinsic value and self-efficacy ($r = 0.703$) are strongly related. Intrinsic value and presentation anxiety ($r = -0.075$), and self-efficacy and presentation anxiety ($r = -0.098$) exhibited an inverse, yet weak correlation.

Spring Semester Findings

This study considers the spring semester motivation data. Students self-evaluated their motivation levels on the adapted MSLQ survey at the end of the senior capstone design course. The average scores of each motivation factor are analyzed to check the dependency. Covariance analyses are shown in Table 6. Self-efficacy and presentation anxiety have an inverse covariance value of -0.003. It is observed that self-efficacy and presentation anxiety are inversely related in spring semesters too.

Table 6: Covariance Results for Spring semesters of Both Cohorts

	Cognitive Value	Self Regulation	Presentation Anxiety	Intrinsic Value	Self Efficacy
Cognitive Value	0.652				
Self-Regulation	0.465	0.618			
Presentation Anxiety	0.425	0.555	2.490		
Intrinsic Value	0.262	0.183	0.080	0.562	
Self-efficacy	0.243	0.201	-0.003	0.396	0.569

Table 7 presents the correlation between motivation factors. It is observed that cognitive values and self-regulation are positively correlated (0.7327). There is also a stronger correlation between intrinsic value and self-efficacy. Self-efficacy and presentation anxiety are not correlated (-0.002). It is similar to fall correlation analysis, both negatively correlated. Though previous studies indicated a change in student motivation throughout the semester, the correlation indicates that no major change in correlation is observed between data collection instances. This serves as an indication of the reliability of the instrument.

Table 7: Correlation Results for Spring semesters of Both Cohorts

	Cognitive Value	Self Regulation	Presentation Anxiety	Intrinsic Value	Self Efficacy
Cognitive Value	1				
Self-Regulation	0.733	1			
Presentation Anxiety	0.334	0.447	1		
Intrinsic Value	0.434	0.311	0.067	1	
Self-efficacy	0.400	0.339	-0.002	0.700	1

Table 8: Change in correlation Δr

	Cognitive Value	Self Regulation	Presentation Anxiety	Intrinsic Value	Self Efficacy
Cognitive Value	0				
Self-Regulation	0.082	0			
Presentation Anxiety	0.064	0.057	0		
Intrinsic Value	-0.117	0.032	0.142	0	
Self-efficacy	-0.088	0.074	0.096	-0.003	0

Correlation of Motivation Vectors Across All Data Points

To determine the correlation considering all data points (both fall and spring semesters for both cohorts), a correlation analysis is performed. As observed in Figure 1, three sets of data are presented. A histogram with density estimations is presented on the diagonal. On the top portion (above the diagonal), the value of the correlation is presented. In the bottom portion (below the diagonal), the bivariate scatter plots with fitted lines are presented. The ellipses are used to display the strength of the relationship. Comparing the fall and spring data together the observation of stronger relation between intrinsic value to self-efficacy and self-regulation to cognitive value is

clear. The size and direction of the ellipse on the bivariate scatter plot is used to determine the linear association between the two given variables. It is clear from the plots that the ellipse direction explains the stronger relationship between cognition and self-regulation, efficacy and intrinsic value, and intrinsic value and cognition.

Only one negative relationship was observed, between anxiety and self-efficacy. Weak relationships observed were between anxiety and intrinsic value, self-regulation and intrinsic value, and efficacy and self-regulation.
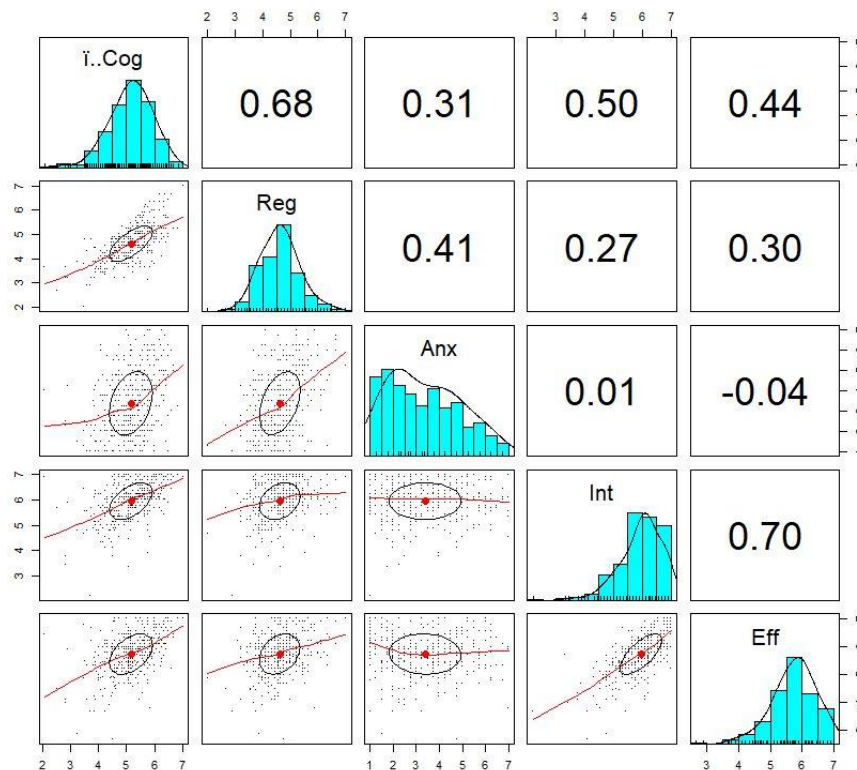

Figure 1: Correlation between Motivation Factors (All Data Points)

Principal Component Analysis: Fall-Spring Semester

A confirmatory factor analysis was performed to ensure the instrument measured its intended purpose. The confirmatory factor analysis – Principal Component Analysis – results are tabulated in Table 9. As seen in the results, the five loadings contributed nearly uniformly to the variation in the data. This analysis indicated that all five factors are needed when measuring student motivation. It details the correlation between factors while considering the variation between factors. The data provided an opportunity to perform a conceptual replica [44] of the MSLQ and adds confidence [45] in the findings of this paper.

Table 9: Factor Loadings for Five Factors

	RC5	RC2	RC4	RC3	RC1
SS loadings	1.03	1.03	1.01	1.00	0.93
Proportion Var	0.21	0.21	0.20	0.20	0.19
Cumulative Var	0.21	0.41	0.61	0.81	1.00
Proportion Explained	0.21	0.21	0.20	0.20	0.19
Cumulative Proportion	0.21	0.41	0.61	0.81	1.00

In addition to the loadings, a factor biplot is presented in Figure 2. The biplot indicates that self-efficacy and intrinsic value are positively correlated due to the relatively small angle. Whereas presentation anxiety and self-efficacy form an angle of 90 degrees, which indicates they are not likely to be correlated. Presentation Anxiety is observed to almost exclusively impact the first principal component. Starting from the left most line (pointing vertical), the vectors represent Self-Efficacy. The following vector on right is Intrinsic Value. The angle between the self-efficacy vector and intrinsic value depicts the presence of correlation. This confirms the results from the previous covariance and correlation analysis. Cognition value vector lies at an angle greater than the angle between self-efficacy and intrinsic value vector. The following vector is for Self-Regulation. The small angle between the cognition vector and self-regulation vector indicates the presence of relationship. Presentation Anxiety vector is observed far from the other vector indicating low relationship.
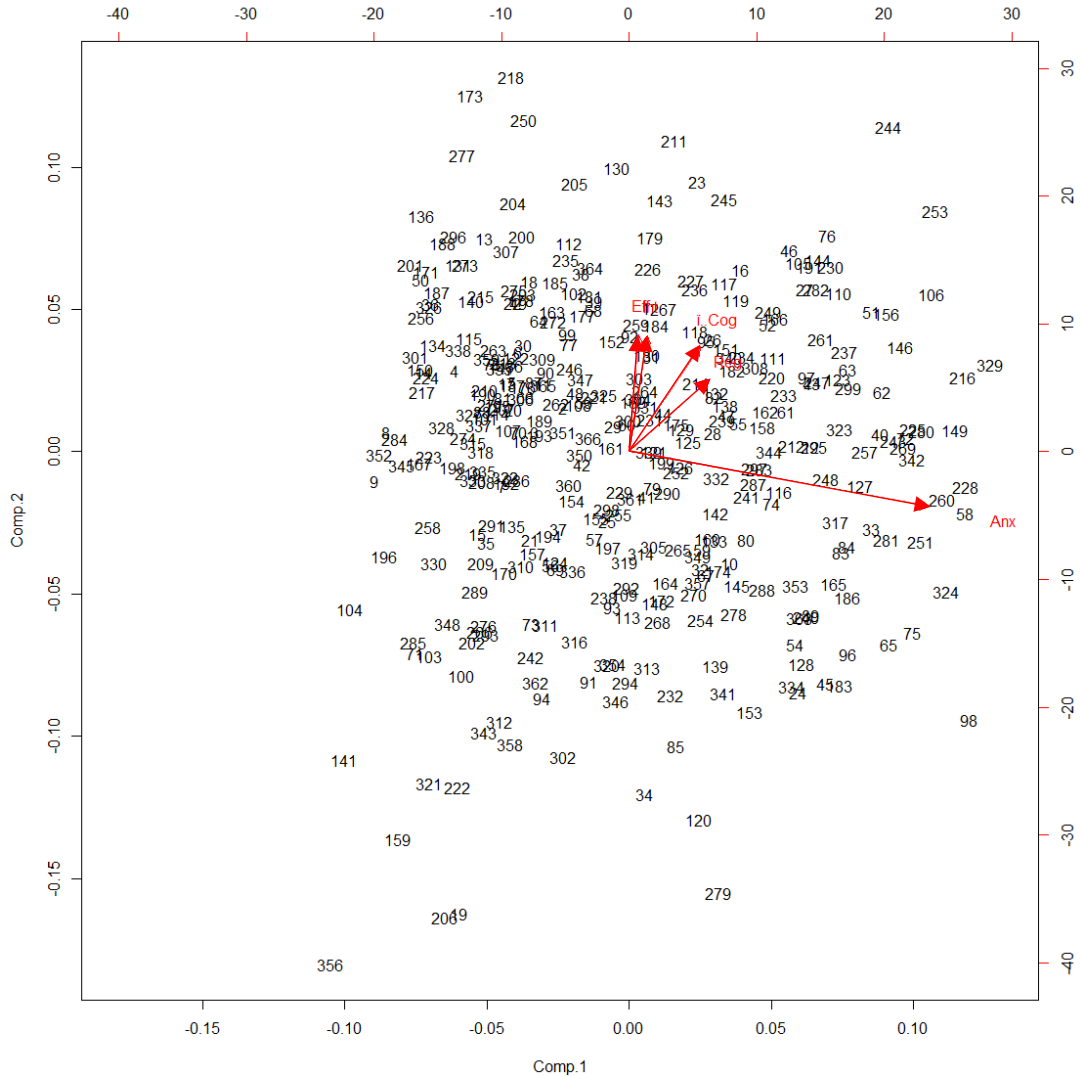
Figure 2: Principal component loading plot

The factor biplot is administered to further examine the orthogonality of the five factors of motivation. It is clear from the plot that the presentation anxiety is orthogonal to self-efficacy and the intrinsic value of student motivation. This is an important observation made in this analysis. However, the relationship between self-regulation and anxiety, and self-regulation anxiety is similar.

5. DISCUSSION

This paper is built on the foundations of a larger case study examining student motivation in engineering programs [46]. The longitudinal study on student motivation conducted at a private institute provides a framework for examining and understanding the factors impacting student motivation in engineering programs through mixed method studies. This paper contributes in

establishing the relationship between the factors. There is no single technique to increase motivation but it can aid in enriching the classroom experience, hence educators must be informed on how one factor (when targeted for improvement) could impact other factors.

This study identifies the existence of a correlation between the five motivation factors through clustering techniques. These five motivation factors were analyzed by a covariance and correlation analysis. It was seen that there was a significant relationship between the factors of motivation which we intended to find based on the role of motivation in student performance from past studies. The second phase determined the orthogonality of the factors. It was seen that presentation anxiety was orthogonal to intrinsic motivation and self-efficacy, with an inverse correlation. This study suggests that there is an existence of a correlation between the factors of motivation and yet these factors are also unique in the variation observed through the confirmatory factor analysis. This is an important study to inform educators measuring student motivation, as the five factors studied here are correlated, that changes in factors will impact other factors and re-administration of the survey instrument will be necessary.

The analysis determines uniformity in variations observed. The results of the covariance and correlation analysis determined that values did not change significantly between the two instances the data was collected. While this can serve as an indicator of the reliability of the instrument, it also demonstrates that students did not change their correlation of motivational factors throughout the senior capstone design experience. For instance, we hypothesized that students would build a stronger correlation between cognition and self-regulation throughout the year as they recognized the in-depth knowledge they gain would impact their ability to perform. This recognition was hypothesized to occur through multiple instances of feedback students received throughout the course.

While the study reinforced the reliability of the instrument, it assists in understanding the positive and negative correlations between factor. This aids educators in relating the dependency and judge the potential impact of one factor on another. A positive correlation between cognition and self-regulation is observed. It can be inferred that a student aiming to achieve self-regulation can have a higher chance of improving their cognition levels but the same cannot be stated for presentation anxiety.

A confirmatory factor analysis is performed here as the instrument was administered to determine the variation of each factor captured and the direction of their loading. The results

indicated that each factor contributed equally to the variation in the data (approximately 20% each), meaning all five factors are equally important in capturing the variation in response. A biplot of two principal components is generated and reveals that many of the factors (with exception of anxiety) possessed a small angle between each other, meaning they were correlated. Anxiety was pointed toward the second principal component and possessed a larger ($>60°$, $<90°$) angle, indicating that there was no correlation.

The findings from this study confirms the existence of correlation between the motivation factors and determines the strength of their relationship, confirming the first hypothesis. The study also successfully established the orthogonality of the five factors, confirming the second hypothesis. This informs educators that intentional change contributing to one factor may impact other factors, thus educators must be cognizant of this relationship. The second research question (regarding orthogonality) revealed that anxiety possessed the most orthogonality, as it was not correlated to intrinsic motivation and efficacy. This is observed both in the biplot and correlation matrix. This indicates that while correlation exists, the factors were unique in the variation they capture.

6. CONCLUSIONS AND FUTURE WORK

This study is a step toward the larger goal of increasing student retention rate in engineering programs. This paper highlighted the relationship between each factor. The five motivation factors were analyzed from the data collected in the previous study. Covariance analysis and principal component analysis were administered. Relationship between the five factors of motivation is established. This study was done using an adapted version of the MSLQ survey, thus the research findings can prove beneficial to the educators who are likely to use this research in their classroom setting for teaching and learning. The fall and spring semester data provide an insight on the presence of relationship and its strength. Covariance and correlational analysis provide the evidence for the relationship and its strength respectively. The principal component analysis determines the orthogonality by using the motivation data of senior capstone design students.

There is evidence on the impact of project type of student motivation; this study adds to that in determining the importance of each factor and its dependency. This team aspires to expand this study further by developing a deeper understanding of the inner-workings of senior capstone design team through mixed method approach and identify the attributes of a successful senior capstone design project to elevate learning and student performance. The authors intend to explore

students journey through interview and qualitative data analysis. Student GPA and industry career would be another avenue to explore and encourage educators in providing enriching experience.

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