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# Investigating Undergraduate Engineering Students' Motivations: An Early-Stage Analysis

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## Abstract

This study examines students' motivations and learning strategies at an undergraduate-level engineering education. The Motivated Strategies for Learning Questionnaire (MSLQ) compares the value engineering students obtain from their education and learning strategies with their expectancy of success, which is the main instructional method in this research. The survey questions split motivational factors into (a) intrinsic goal orientation, (b) extrinsic goal orientation, and (c) task value. Learning strategies can be categorized into more specific groups, including cognitive methods such as rehearsal, organization, and critical thinking. Students may expect success in different forms based on their motivations, which can be associated with their self-efficacy and self-regulation. The overarching research question is, what are the associations between undergraduate engineering students' motivation and learning strategies? This study collects data from a single engineering discipline from thirty-five undergraduate engineering students in Singapore. A statistical analysis method based explicitly on Cronbach's alpha coefficient identifies the reliability of the scales, and the following analysis using the Pearson correlation coefficient and the Mann-Whitney U test provides comparative details. The results convey high correlations between certain motivational factors and learning strategies, as well as specific differences between the results based on the sample in Singapore and an established work based on MSLQ. This could enable an understanding of the effectiveness of undergraduate engineering education in Singapore. Significant gender differences are also observed in specific scales. In accordance with the results, a teaching system based on increasing the value of engineering education for the students could be designed in the future, helping students to further their interest in engineering fields and obtain sustained success. Future studies can be performed to include a larger representative sample and analysis of learning styles not mentioned in the questionnaire.


## Introduction

Engineering education is a treasured field that directs the future of young and bright minds worldwide. Improvement and growth in engineering education could help cultivate better-equipped, capable, and creative engineers—considerable research efforts related to engineering education trial various educational innovations across different learning stages. For example, integrated STEM education, which involves interdisciplinary work that blends STEM subjects into a cohesive instructional flow, has been developed out of necessity to encourage secondary school students to pursue engineering. A previous study has shown that integrated STEM education allows students to be more creative and improve their understanding of science and mathematics [1]. By rendering them more capable and adaptable to developing solutions [2], students can retain information and apply it to existing knowledge [3] [4] [5]. If such teaching methods that support and nurture engineering talents across the globe need to be constructively developed, cognizance of students' motivations and expectations should play a significant role since students’ interests in design-related practices strongly correlate with their expectancy for success in those tasks and subjects [6] [7].

Understanding students' learning processes could help educators integrate self-regulated learning into their classes [8], as self-directed learning has become increasingly important in a digital ecosystem with online learning protocols. The emergence of instructional approaches such as flipped classroom, which allows learning at one’s own pace, indicates an essential transformation within the style of education for educators to be more involved and update their instructional techniques. This requires educators to identify the students who need support in regulating their learning early on.

This study explores undergraduate engineering students’ motivation and learning strategies. The findings serve as a relevant reference for designing instructional methods in the field of undergraduate engineering education. The overall research questions can be identified as follows:

1. What are the relationships between undergraduate engineering students' motivational factors and learning strategies?
2. What are the distinctive characteristics of motivational factors and learning strategies of undergraduate engineering students in the Southeast Asian region?
3. Are there any significant differences between subgroups (e.g., gender, year of study, student status) in the different categories of motivational factors and learning strategies?

**Related Studies**

Learning styles are expected to vary widely in a multicultural classroom due to varying educational backgrounds that lead to different preferences. However, according to a study comparing classrooms in the USA and Bangladesh, within engineering, the learning styles were observed to be similar across cultural backgrounds [9]. Engineering students showed a preference for physical learning that involved active senses [10]. Mazumder and Karim [9] also provided a variance between senior students and freshman students who showed differences in their learning styles, specifically in the sensing and intuitive dimensions. Zurita et al. used the Motivated Strategies for Learning Questionnaire (MSLQ) to establish that in Spanish higher education, students who self-regulate their learning could control their learning and motivation more effectively [11].

Southeast Asia has a small population, and Singapore has a mere 5.92 million people [12]. More than five thousand engineering degrees are awarded annually to people in Singapore [13], and with the country expecting only 9% to 18% of its citizens in STEM and engineering careers [14], these engineers must be focused and capable. There is an increasing demand for engineers in Singapore, with salaries rising to encourage talent to enter the employment market [15]. It is a fair assumption that the demand for engineers will increase in the future with technological advancements. This implies action to take place in the present that brings about educational innovations to inspire engineers to stay in the market and provide the technical expertise that ushers the future to the fore. Understanding students' motivations can improve the engineering education curriculum in Singapore and motivate students to continue in the field. Providing engineering educators with the knowledge of student motivations could allow lessons and teaching to be tailored around students' expectations and provide an education that encourages independence, self-efficacy, self-regulation, and innovative development.

In Southeast Asia, Singapore in particular, human resources, especially in engineering domains, are crucial to devising solutions to mitigate the impacts of climate change and the aging population [16], ensuring sustainability, improving economic growth, as well as promoting social progress. In the current intelligent and knowledge-intensive era, preparing young minds in university to become all-set contributors for current and future challenges is essential [17]. Therefore, success in university education is fundamental in producing holistic talents who can apply subject knowledge to design and innovate to address the challenges Singapore faces as they graduate and enter the workforce.

Gender differences in engineering education have gained increasing attention as more women choose to take a career path as an engineer. Ohland et al. [18] indicated that gender differences in multiple measures of success for engineering students are enormously surpassed by radial differences and institutional differences. Specifically for motivation, a study conducted by Kilgore et al. [19] illustrated that men and women share great similarities in motivation except for influences from hands-on work and mentors, which give educators implications on methods to captivate engineering students. For this research, rather than engineering-specific motivational factors, general motivational factors along with learning strategies are probed, as this research focuses on the pedagogical design specifically, not considering other fairs related to the motivation, such as recruitment and activities that do not pertain to engineering education.

## Method

The data is collected using a closed-ended questionnaire that is self-administered on an online survey platform. The questionnaire covers their experiences with the class content, the value, and the interest students gained from their previous course study. The questionnaire aims to numerically comprehend students' motivations and beliefs about their academic ability. The survey also focuses on the learning strategies that students find effective in their education to provide the researchers with an understanding of the future methodology of engineering education and growth.

### *Participants*

The study's focus group is a group of undergraduate engineering students who study full-time at an internationally recognized university in Southeast Asia. The sample group contains 35 students from a single engineering discipline. The students who have participated in the study consent to the use of the information as long as it remains anonymous. Therefore, the data collection process does not involve the collection of names or email addresses that could directly identify individuals who have completed the questionnaire. Table 1 shows the demographic information of the survey participants. 26 respondents are male, and 63% of participants are local citizens. It provides a representation of the university demographics.

Table 1. *Demographics of survey participants*

| **Category** | **Sub-Category** | **Frequency** | **Percent (%)** |
|---|---|---|---|
| Gender | Male | 26 | 74.3 |
| | Female | 9 | 25.7 |
| Study Year | First | 8 | 22.9 |
| | Second | 14 | 40 |
| | Third | 10 | 28.6 |
| | Fourth | 3 | 8.6 |
| GPA | 4.51 - 5.00 | 9 | 25.7 |
| | 4.01 - 4.50 | 13 | 37.1 |
| | 3.51 - 4.00 | 3 | 8.6 |
| | 3.01 - 3.50 | 8 | 22.9 |
| | 2.51 - 3.00 | 1 | 2.9 |
| | 2.01 - 2.50 | 1 | 2.9 |
| Student Type | Citizen | 22 | 62.9 |
| | Permanent Resident | 4 | 11.4 |
| | International | 9 | 25.7 |

***Instrumentation***

To measure undergraduate engineering students' levels of different motivational factors and learning strategies, the Motivated Strategies for Learning Questionnaire (MSLQ) is utilized as the instrument in this study [20]. The MSLQ is a self-report survey involving eighty-one items that measure motivation and effective learning strategies for students enrolled in a college course. Originally titled “A Manual for the Use of the Motivated Strategies for Learning Questionnaire” and published by Pintrich [20], this questionnaire split six factors for the motivational scales and nine factors for the learning strategies scales, which can be used by researchers collectively or individually. Under the section relating to motivation, there are 31 items relating to the motivations and reasoning students have in pursuing their undergraduate education. This also involves areas such as their goal orientation, self-efficacy beliefs, and assessment-based anxiety. The learning strategies section contains a total of fifty items, which relate to students’ cognition and metacognition as well as their management of various resources in their learning process. Each item is a statement, such as “It is important for me to learn the course material in this class.” The students are then asked to respond on a seven-point Likert scale, with position seven labeled as ‘very like me’ and position one labeled as ‘very unlike me.’

### *Validity*

An initial pilot survey is conducted to collect feedback and check the validity of the responses from participants who are not part of the sample population. The feedback from the participants involves the length of the survey. The participants are encouraged to take breaks and respond to the survey in a comfortable setting. Such provisions are reasonable since the results are collected through an online survey platform, and the link was shared with only the study's focus group. Since the online platform stores the information securely that the participant has already entered without providing the researchers with identifying information, it follows the privacy protocols to ensure participants are comfortable with the survey.

### *Reliability*

Cronbach’s alpha coefficient measures the consistency of the data concerning the MSLQ and identifies the reliability of the results. Through testing on the validity of the MSLQ, it has been shown that the items in the motivational section of the MSLQ have significant correlations with the final grade in the course [21]. The fifteen subscales under motivation and learning strategies have been shown to represent the MSLQ as an empirically validated measure that can then be used to understand students and develop the future of university engineering education. The Cronbach’s alpha coefficient for each scale is measured to check the internal consistency of the data collected and to understand the relevancy of specific scales in the Southeast Asia region.

### *Data Collection*

The data is collected via an open electronic invitation to participate. Along with the MSLQ, the demographic information is anonymously collected from the students, including their gender identity, age, year of study at the university, educational qualifications of the student, ethnicity, and grade range, as well as their student status as a citizen, a permanent residency holder, or an international student. International students are important in the context of a globally ranked university with a significant student population that is not from Singapore. International students consider a lot of different factors, including the academic, social, and cultural environment of their university choice.

### *Data Analysis*

The demographic information collected from the participants is used to order them into groups and observe the difference in motivations and learning strategies in groups across local or international students, age groups, and various educational backgrounds. Kurtosis and skew coefficients are obtained for each scale based on specific demographic splits. Looking at the statistical description of the data on the Likert scale, trends can be identified to relate the MSLQ scales to student grades. It can be observed whether the responses are consistent within the sub-groups of motivation and learning strategies like ‘intrinsic goal orientation,’ ‘test anxiety,’ ‘critical thinking’, and ‘peer learning. The Mann-Whitney U test is used to provide a correlative factor, as it indicates whether there is a statistical difference between two different demographic groups.

## Results

The lowest reliability within this data set, seen in Table 2, is observed in the ‘Test Anxiety’ and ‘Help Seeking’ scales. This could suggest that these are less important within the Southeast Asian context. Data represented by Pintrich [20] align with the ‘Help-Seeking’ aspect, displaying a similar alpha coefficient of 0.52. However, on the ‘Test Anxiety’ scale, there is a significant difference between the study’s 0.56 and Pintrich’s 0.80. That could suggest that test anxiety is not important within this region or it has become less important over the last 30 years since the appearance of the MSLQ. Self-efficacy is shown to be a reliable construct, with a measured 0.96 alpha coefficient, which is higher in comparison with Pintrich’s 0.93. Intrinsic goal orientation is also shown to be a more reliable scale compared to Pintrich’s 0.74. This could indicate that the region’s students are not as motivated by external factors but rather focus more on their intrinsic goals as well as self-efficacy-related factors in their motivation to pursue engineering.

Narrowing the focus specifically to the scales with Cronbach’s alpha above 0.7, which demonstrates the strongest internal reliability, those data are further analyzed. Using the Kurtosis and skewness test, outliers in the distribution are measured and checked. To provide a sample of the value of this data, a primary exploration is conducted concerning student “self-efficacy,” “task value,” and “intrinsic goal orientation” (IGO) in the motivational scales and “effort regulation,” “critical thinking,” (CT) “elaboration,” “rehearsal,” and the “time and study environment” (TSE) in the learning strategies scales. The internal correlations among those factors are represented by the Pearson correlation coefficients.

Table 2. *Cronbach's alpha for the MSLQ scales in the sample*

| **Motivational Scales** | **Cronbach's Alpha** | **Learning Strategy Scales** | **Cronbach's Alpha** |
|---|---|---|---|
| Test Anxiety | 0.56 | Help-Seeking | 0.53 |
| Self-Efficacy | 0.96 | Peer Learning | 0.63 |
| Control of Learning Beliefs | 0.67 | Effort Regulation | 0.70 |
| Task Value | 0.81 | Time and Study Environment | 0.84 |
| Extrinsic Goal Orientation | 0.59 | Metacognitive Self-regulation | 0.68 |
| Intrinsic Goal Orientation | 0.81 | Critical Thinking | 0.74 |
| | | Organization | 0.64 |
| | | Elaboration | 0.83 |
| | | Rehearsal | 0.83 |

The Pearson correlation coefficients are calculated based on the aggregate scores for each scale. The negative scoring items in the MSLQ were reversed to ensure uniformity and accuracy, and then these reversed values were used to calculate the Pearson correlation coefficients. As shown in Table 3, the correlations among the motivational and learning strategy scales are generally significant. "Intrinsic Goal Orientation" shows the highest correlation between a motivational scale and a learning strategy scale with "Elaboration." Within motivational and learning strategy scales, "elaboration" and "critical thinking" show a strong positive correlation, while "intrinsic goal orientation" and "task value" show a strong correlative relationship. This suggests that these motivational scales and learning strategies are related and work together for undergraduate engineering students.

The critical value for the Mann-Whitney U test is 64 for a sample size of twenty-six males and nine females [22]. This means that, apart from the self-efficacy scale, it can be observed that there is a significant difference between the motivational scales and the learning strategies scales for males and females at the two-sided 0.05 significance level in Table 4. A U value above 64 represents no significant difference between male and female undergraduate engineering students. The motivational factor 'self-efficacy' is the only one that obtains a U value below 64.

Table 3. *Summary of Pearson correlation between selected scales*

| **Scales** | **IGO** | **Self-Efficacy** | **Task Value** | **Effort Regulation** | **TSE** | **CT** | **Elaboration** |
|---|---|---|---|---|---|---|---|
| Self-Efficacy | 0.617* | | | | | | |
| Task Value | 0.748* | 0.586* | | | | | |
| Effort Regulation | 0.455* | 0.587* | 0.471* | | | | |
| TSE | 0.470* | 0.603* | 0.398* | 0.761* | | | |
| Critical Thinking | 0.470* | 0.560 | 0.537* | 0.558* | 0.432* | | |
| Elaboration | 0.671* | 0.585* | 0.571* | 0.587* | 0.519* | 0.712* | |
| Rehearsal | 0.087 | 0.102 | 0.174 | 0.342* | 0.201 | 0.475* | 0.389* |

*Note:* *Correlation is statistically significant at the 0.05 level (2-sided p-test)

Table 4. *Summary of initial data analysis of male and female mechanical engineering students*

| **Scales** (Number of Items) | **Male** Mean (SD) | **Female** Mean (SD) | **Kurtosis** M/F | **Skew** M/F | **Mann-Whitney U.** |
|---|---|---|---|---|---|
| IGO (4) | 20.11 (3.77) | 16.89 (5.93) | -0.014/2.178 | -0.192/-1.069 | 77 |
| Self-Efficacy (8) | 39.31 (9.07) | 25.67 (13.30) | 0.608/-1.029 | -0.704/0.063 | 47 |
| Task Value (6) | 31.62 (5.46) | 28.11 (7.57) | 1.400/-0.523 | -0.849/-0.627 | 86.5 |
| Effort Regulation (4) | 17.85 (3.65) | 17.78 (2.82) | -0.670/-0.091 | -0.025/0.417 | 114.5 |
| TSE (8) | 39.69 (8.34) | 34.11 (11.21) | 0.176/-0.813 | -0.597/0.352 | 81.5 |
| Critical Thinking (5) | 22.92 (3.97) | 19.44 (8.05) | -0.619/-0.564 | -0.032/-0.512 | 93.5 |
| Elaboration (6) | 31.08 (4.84) | 26.78 (8.84) | 0.988/4.29 | -0.725/-1.394 | 77 |
| Rehearsal (4) | 17.65 (5.36) | 17 (7.16) | -0.315/-0.133 | -0.515/-0.861 | 113.5 |

**Discussion**

This is an early analysis that can provide insights into the value of the data collected, with further empirical data to be analyzed and discussed in the next submission. Note that as seen in the result section, the ‘Intrinsic Goal Orientation’ scale is relevant to the motivation of students, and ‘Self-efficacy’ has shown the highest internal reliability. These represent the importance and value placed on these two motivational and learning scales within the context of Southeast Asian undergraduate engineering students.

Learning strategies that focus on rote learning and memorization would not be as effective as analytical problem-solving, which encourages self-regulation and metacognition in engineering. This can be seen in the results, where ‘rehearsal’ is consistently lower ranked by students. Moreover, this is shown to have a lower significance and correlation with other factors compared to the other reliable learning strategies measured, like ‘self-efficacy’ and ‘critical thinking.’ The ‘time and study environment’ is generally valued for students to better understand the content taught in engineering courses, and indeed, students place significant value on it.

In comparison with similar veins of studies conducted utilizing the MSLQ, comparisons can be made with existing studies. For instance, Wee et al. [23] conducted a study at a university in Malaysia, surveying accounting students. Their study observed a higher mean score concerning extrinsic motivation, above the U.S. average mean. This involved a sample of over 500 students in Malaysia and 380 students in the U.S. This relies on mean ratings on the Likert scale, and by comparing the reliability values, it can also be observed that extrinsic motivation is more relevant to students in accounting in Malaysia compared to the sample within this study. This could be relevant in comparisons between engineering and accounting students, but it is also important to note that this study was published in 2006, and it could also be used as a point of comparison between undergraduate students 18 years old. Further studies in engineering in the region could provide the most context for improvements that can be made to the engineering education process.

In contrast to negligible gender differences in engineering education revealed by previous studies [18] [19], the result shows a significant disparity between genders in the motivational factor ‘self-efficacy’, and male students have a higher average score than female students on that scale. This finding indicates that the gender difference in students’ self-efficacy should not be ignored when designing and implementing engineering curricula. It is important to provide additional support to female engineering students in developing their self-beliefs regarding their potential for success in engineering education and careers.

Through the study's outcomes, universities may realize that students require more active and direct learning to enjoy engineering. Improved learning strategies allow students to form connections between information and allow information to be stored in longer-term memory, which helps develop better engineering undergraduates [20]. Having an integrated curriculum could improve their motivation to pursue engineering, as demonstrated by Everett et al. [2], due to the emphasis placed on intrinsic goals and task value. Furthermore, the growth of online learning platforms, especially because of distance learning due to the necessity of the COVID-19 pandemic, surveys, and performance identifiers in a flipped classroom, could be greatly beneficial in encouraging university students to self-regulate their learning and generate ‘self-efficacy’ [8].

Understanding the students' learning strategies could benefit educators in higher-level institutions. Reminding the professors or peer tutors to revise courses that emphasize rote memorization or rehearsal less than they did in the past could allow them to revise the course program to focus on critical thinking instead. Having motivated and self-regulated students could result in capable engineers interested in continuing their pursuit of engineering and encouraging foreign engineering talent into the Southeast Asia region.

These initial results present the possibilities of comparable data from just 35 respondents, with a significant difference between the male and female respondents. This analysis captures only part of the MSLQ, and further analysis can be done to compare the internal relations with the additional demographic information of undergraduate engineers. Expanding the data set within the university itself could provide more reliable data and allow stronger generalizations to be made. While this study focuses on a small number of participants in undergraduate engineering at a specific university, there could be a case to compare results across other regional universities.

Further analysis could reveal a vast distribution and variation among learning styles for engineering students. Research from Nancekivell et al. [24] suggests that learning styles are a myth, which is simply a perception that one learns better when taught in a dominant learning method such as auditory, visual, or kinesthetic. Beliefs among students and educators concerning these learning styles are “more complex and variable than previously recognized.” This could suggest that there is a lot about the methods of education that are yet unknown, and statistical analysis of the data collected with the grades of the students in this study could provide insights into the Southeast Asia region that identifies whether specific learning strategies play a greater role in the performance of engineering undergraduate students.

## Conclusion

This study investigates undergraduate engineering students' motivations and learning strategies. The correlations between different motivational factors and learning strategies, as well as the differences between subgroups on certain factors, are evaluated in this research. Students ' learning strategies and motivational factors are measured through an online questionnaire based on the Motivated Strategies for Learning Questionnaire (MSLQ). After conducting essential reliability tests for the scales in the questionnaire using Cronbach’s alpha coefficients, these coefficients are compared with those in a prior study to identify the attributes of engineering students in the Southeast Asia region, especially in Singapore. Factors with strong reliability are further processed. Pearson’s correlation coefficients between different scales are calculated to examine relationships among distinct motivations and learning strategies. In addition, the gender differences in motivational factors and learning strategies are examined by the Mann-Whitney U test. General correlations are found among most of the scales. The reliability test shows that undergraduate engineering students in Southeast Asia are driven more by their intrinsic motivations than external factors, and self-efficacy plays a crucial role in motivating those students. Moreover, female students have a lower average score than male students in the ‘self-efficacy’ scale. By indicating relatively vital motivational factors and learning strategies, the results of this research can assist in the development of engineering curriculum design in the Southeast Asia region. The findings can also be used to compare regional features in engineering education. Future studies can be conducted to expand the sample, enhance its representativeness, and consider a wider range of learning strategies. Besides examining gender differences, potential variations in other subgroups can also be analyzed in the future.

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