WIP: First-year Engineering Students' Study Strategies and Their Academic Performance

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Work in Progress: First–year engineering students' study strategies and their academic performance

Abstract

Utilizing effective study strategies is one of the key predictors of students' academic performance (e.g., [1]). However, in engineering education, there are a few studies that explored this relationship in real classroom settings throughout an academic semester. This work in progress paper investigates the relationship of engineering students' study strategies and their academic performance in a required first-year engineering course. For this study, data was collected from 161 engineering students at a large Midwestern university. We collected data by asking students to reflect on their study strategies that they used for the preparation of course exams. This course had three exams for student evaluation over the semester. We used these exam scores as a measure of their academic performance, which were graded by the instructional team. From this data, we addressed two research questions: 1) To what degree do students' selection of study strategies vary while preparing for exams? 2) How do students' study strategies relate to their academic performance in exams? To answer the first question, we conducted one-way ANOVA to test the variability in the students' selection of study strategies over the exams. And for the second question, we performed a bivariate linear regression to analyze the relationship between students' study strategies and students' academic performance. Our preliminary results revealed that there was a significant change in the frequency of the selection of student study strategies over the exams, and the most significant variation existed between the first and third exam. However, the results of the regression analyses showed no significant relationship between the frequency of the students' study strategies and their academic performance in all exams. While this paper is work in progress paper, we in our future studies aim to explore it further by looking at different aspects of study strategies, and by seeing the difference between low and high achieving students.

Keywords: study strategies, first-year engineering, academic achievement, learning strategies

Introduction

High-quality engineering education is vital for the civic, economic, social, and technological progress of the country. Well established engineering disciplines prepare a skilled labor force that can develop products and processes for different aspects of the society, such as medical care, defense, and resource management. Rosenberg and Nelson [2] stated that one of the reasons behind the U.S. economic dominance was the initiatives to develop and institutionalize the engineering disciplines. However, the current situation of U.S. engineering education is not as bright as it used to be on the global stage. For instance, according to the National Academy of Engineering [3], there is a low percentage of students graduating with engineering degrees in the U.S. compared to the rest of the world. This creates a shortage of skilled engineers required to keep pace with the rest of the world in terms of technological and industrial development. Therefore, there is a significant emphasis on improving engineering education in the United States. For instance, in a report by the U.S. National Academy of Engineering titled "Educating the engineer of 2020" [4], it was recommended that engineering education be reinvented. The same report discussed the importance of understanding the students' learning challenges and devising better pedagogical approaches to improve engineering education. Along the same lines, one of the grand challenges [5] in the engineering outlined by the U.S. National Academy of Engineering is to improve the personalized learning experience and develop a self-directed attitude among the engineers.

In order to counter the presently faced challenges, it is important to understand the root cause behind the declining number of graduating engineers. A large body of literature shows that 40% of the students who failed in their first year of engineering courses ultimately dropped-out of the engineering discipline [6]–[8]. For this purpose, it is crucial to understand students' acquisition of fundamental engineering concepts and skills. Therefore, it is important to explore students' study strategies employed to learn a particular concept or topic. By understanding these strategies, the pedagogies can be altered to incorporate these strategies that could facilitate the learning process and develop a self-directed attitude to learn about concepts or skills.

In this work in progress, our overarching goal is to understand the relationship between first-year engineering students' study strategies and their academic performance. For this purpose, we analyzed a course offered to first-year engineering students at a large midwestern university. First-year engineering students were involved in reflective thinking practice. In this reflective practice, they were asked about their study strategies to prepare for the exams (three exams) before each exam. This study is vital because there are limited studies within the engineering domain studying the study strategies of the engineering students. Also, this study will contribute to the understanding of the study strategies applied by students to keep up with engineering courses, especially demanding courses like computer programming. More specifically, this paper has explored these two research questions: 1) To what degree does the frequency of students' selection of study strategies vary while preparing for exams? 2) How does the frequency of students' study strategies relate to their academic performance in exams?

Literature Review

A large body of literature has discussed the concept of the students' study strategies. However, there is still a lack of consensus on the concept of the study strategies [7] or even the term "study strategies." Some educational psychology studies argued that the study strategies comprise of the students' behaviors related to learning, such as the ability to organize information, planning, motivation, and so on [9], [10]. Also, Graham & Robin [11] considered study strategies as the specific processes taken by the students to learn a specific topic.

Prior studies have researched the relationship between study strategies with students' academic achievement. For instance, Sangiry and colleagues [12] have studied the different factors responsible for the academic achievement of pharmacy students. They found that time management (prioritizing the content for the exam preparation) and study strategies (while studying, ability to guess the important questions for the exam, summarization of the course material in their own words) are the two key predictors for the students' academic achievement. Another study [13] examined the relationship between study strategies and academic achievement among undergraduate students at a Spanish university. They found a strong relationship between students' study strategies and their academic achievement. Within the context of first-year students, prior studies have established that poor study strategies are the key predictors of failure among the first-year college students [14]–[16].

The surveyed literature revealed that limited research had been focused on the study strategies in the engineering education domain. For instance, one study [17] explored the learning strategies preferences among engineering students. They found different learning strategy profiles among the engineering students, i.e., 33.3% are navigators (students who plan their learning), 39.5% are problem solvers (students who like to explore alternative ways for achieving a particular learning goal), and 27.2% are engagers (students who enjoy learning those topics which they find fun). Another study [18] explored the relationship between first-year engineering students' learning strategies with their self-esteem, intellectual functioning, and academic achievement. A significant correlation was found between learning strategies and other factors. However, there is a further need for research to investigate the study strategies employed by engineering students, especially first-year engineering students, so that the root cause behind the increasing failure can be understood and subsequently addressed. Hence, this study will contribute to the existing literature by answering the fundamental questions posed on the different types of study strategies and their relationship with students' academic achievement.

Research Methods

Site

The data was collected from two sections of required first-year engineering course at a large midwestern university. The topics covered in this course were data visualization and analysis, engineering design, ethics, programming concepts by using MATLAB software, and the development of mathematical models to solve the engineering problems collaboratively. The research team didn't impact the site selections.

Participants

There was a total of 161 student participants in this study. We collected students' reflection responses about the employed study strategies before each exam (three exams). Also, we have respective grades of students for each exam. Table 1 provide the ethnicity and gender distribution of the students' data:

Table 1. Gender and ethnicity information of 161 engineering students

	No of Students
Gender	
Male	102
Female	53
Didn't answer	6
Ethnicity	

White	116
Asian	18
*Underrepresented Minority	7
International (of any ethnicity)	9
Didn't answer	11

** The Underrepresented Minority category in this institution includes any indication of American Indian or Alaska Native, Black or African American, Hispanic or Latino, or Native Hawaiian/Other Pacific Islander.*

Data collection

In the course, the instructor designed a graded activity for the students before each exam to understand their study strategies for the preparation of exams. Before each exam, students were asked the following question:
While preparing for Exam, what actions did you take to help you attain proficiency with the Learning Outcomes? Check all that apply.

- Referred to Learning Objectives (LOs) that lists each LO with its evidence of proficiency.
- Watched and took notes on the online modules
- Used the "help" function in MATLAB
- Googled for help
- Asked questions of my classmates or study group
- Tried the practice exam problems
- Reviewed my performance on the Learning Objectives (LOs) for one or more problem sets
- Reviewed the formula sheet

The student could choose multiple options from the study strategies' options. We also collected students' exam scores for each exam. The study strategies were determined by the instruction team aligned with the course contents. Hence, they were questions related to MATLAB. The instructional team evaluated the exams, and the maximum score for each exam was 120. The study was conducted in accordance with the IRB protocols stated by university.

Data Analyses

Hypothesis

For the first research question, the null hypothesis (H_0) states that there is no difference between the frequency of the study strategies used by the student while studying in their exams:

$$H_0: \mu_1 = \mu_2 = \mu_3$$

Where μ is the population mean. The alternative hypothesis (H_1) states that there is a certain variation in the frequency of study strategies used by the students to study for their exams.

However, in terms of population mean, our alternate hypothesis states that the related population means are not equal:

$$H_1\text{: Not all means are equal}$$

For the second research question, linear regression was conducted between exam scores and the frequency of study strategies chosen by students. However, for this analysis, the null hypothesis (H_0) states that there is no relation between the frequency of the study strategies and exam scores, and the alternative hypothesis (H_1) states that there is a relationship between the frequency of the study strategies and exam scores.

For our first research question, a Repeated Measure ANOVA was conducted. In this analysis, the dependent variable is the frequency of the study strategies chosen by the students, and the independent variable is exam times. Here, the frequency of study strategies means the number of strategies selected by any student on average to prepare for the study. For conducting Repeated Measure ANOVA, our data must satisfy the following assumptions [19]: normality, independence within a group, homogeneity of variance, and homogeneity of covariance. Hence, we conducted a descriptive analysis for the frequency of study strategies, as shown in Table 2:

Table 2. Descriptive statistics of the frequency of the study strategies for each exam

	Exam 1	Exam 2	Exam 3
Mean	5.5839	5.2422	4.5776
Std. Deviation	1.78031	1.94864	2.14953
Skewness	-.597	-.274	-.184
Kurtosis	-.349	-.846	-.927

Table 3. Mauchly's test of sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]	
					Greenhouse-Geisser	Huynh-Feldt
Exams	.990	1.554	2	.46	.990	1.000

For normality, from the skewness and kurtosis values of the descriptive statistics in table 2, we can say that our data is normally distributed. The second assumption is also satisfied because we observed the same participants between the groups and different within-groups. Hence, we can assume that this assumption holds for our data. Together, homogeneity of variance and covariance are also known as the sphericity assumption. To test the sphericity assumption, we ran Mauchly's test of sphericity. The rest result was insignificant as shown in table 3. Therefore, we used the adjusted degree of freedom for our repeated measure analysis.

For our second research question, we conducted a simple linear regression between exam scores and the frequency of the selected study strategies for each exam. In this analysis, the criterion variable is the students' respective exam score, and the frequency of strategies chosen by the students in each exam will be the predictor variable. Descriptive statistics for the exam scores are shown in table 4.

Table 4. Descriptive statistics of each exam score

	Mean	Std. Deviation
Exam 1	103.0621	10.68677
Exam 2	105.8749	8.23540
Exam 3	104.8944	11.55238

Results

To find if there is any difference in the frequency of the students' choosing study strategies while studying for their exams, we ran repeated measure ANOVA. In the previous section, we have discussed the variables and assumptions of the test. For this analysis, we used 0.05 as the level of significance. We can see from table 5 that repeated measures ANOVA with a Greenhouse-Geisser correction determined the frequency of students' selection of study strategies for the three exams varied significantly between exams and has medium-sized effect, $F\ (1.981, 316.918) = 25.658$, $p < .05$ ($\eta_p^2 = 0.1382$).

Table 5. Tests of within-subjects effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Exam	84.302	1.981	42.561	25.658	.000
Error (Exam)	525.698	316.918	1.659		

To further understand the frequency variability of the students' study strategy selection between the exams, we ran a post hoc test using the Bonferroni correction, as shown in table 6. The analysis revealed that the frequency of the students' selection of study strategies for the preparation of exams significantly varied between each exam ($p < .05$), as shown in table 6.

Table 6. Bonferroni post-hoc test (Pairwise comparisons)

(I) Exam	(J) Exam	Mean Difference (I-J)	Std. Error	Sig.[b]
1	2	.342*	.137	.041
1	3	1.006*	.142	.000
2	3	.665*	.149	.000

For the next subsequent research question, 'do the frequency of students' study strategies relate to the students' academic performance in exams?'. We did a simple linear regression for each exam (three exams) with the frequency of students' selected strategy. For this analysis, we used 0.05 as the level of significance.

Table 7. ANOVA results

Exam		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.604	1	2.604	.023	.881[b]
	Residual	18270.525	159	114.909		
	Total	18273.129	160			
2	Regression	215.372	1	215.372	3.220	.075[b]
	Residual	10636.131	159	66.894		
	Total	10851.503	160			
3	Regression	55.293	1	55.293	.413	.521[b]
	Residual	21297.912	159	133.949		
	Total	21353.205	160			

The analysis of regression showed that the frequency of study strategies cannot significantly predict any of the exam scores as shown in the table 7. The results, for exam1, $F(1,159) = .023$, $p< .05$, $R^2 = .00$ using the following equation Exam1 = -.072(frequency of study strategies) + 103.462, for exam 2, $F (1,159) = 3.220$ $p< .05$, $R^2 = .020$ using the following equation Exam2 = -.595 (frequency of study strategies) + 108.996 and for exam 3, F(1,159) =. .413, $p < .05$, $R^2 = .003$ using the following equation Exam3 = -.072(frequency of study strategies) + 1106.146.

Discussion and Conclusion

For this study, a reflective activity was employed to collect the preferences of first-year engineering students. Our analysis revealed that even though there was a change in the frequency of the selection of study strategies over three exams by students, there was no significant relationship between academic performance and the frequency of the students' study strategies. The primary aim of this study was to investigate the relationship between first-year engineering students' study strategies and their academic performance. To answer our primary research question, this study also examined the changes in the frequency of the selection strategies over the three exams. To this end, analysis revealed that there was a change in the frequency of the selection of study strategies. Also, from table 7, it is quite evident that the largest change occurred in the employed study strategies from exam 1 to exam 3. This change can be attributed to the increasing difficulty of the contents in the exams. Hence, the students were trying to employ more study strategies to prepare themselves for the exams. Therefore, this analysis encouraged us to conduct our second analysis to investigate the relationship of the frequency of study strategies and their exam scores.

In our second analysis, the study found no significant relationship between academic performance and the frequency of study strategies. Our result was contrary to the literature found outside the engineering education domain [20]-[22] that establishes a relationship between the study strategies and student academic performance. The following two factors could have impacted our results. One, the students may have selected strategies because of the graded nature of the data collection activity. Second, it might be possible that rather than a number of selected strategies, the effectiveness of certain selected strategies impacts the students' performance. Therefore, future analysis will explore the relationship between the effectiveness of different study strategies and students' academic performance.

Limitations

Like any other experiment, this study comes with its limitations, One, this was an exploratory research study, the statistical significance of the analysis has limitations compared to an explanatory research study. Second, this study collected data only for a limited set of students. The result would have been enriched, if the study had included other similar courses. Finally, a more advanced analysis could have informed us about the effectiveness of certain study strategies.

Future directions

Based on this study which is a work in progress, a few future directions could be suggested. First, future studies can be conducted to find out the effective study strategies and establish their relationship with academic performance. Second, longitudinal studies to identify the relationship and impact of employed study strategies on the students' academic performance over the course of their engineering degree should be conducted. Finally, the researchers may include motivational factors to discuss the relationship between the students' study strategies and their academic performance.

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