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RELATIONSHIP BETWEEN LEARNING APPROACHES AND ACADEMIC PERFORMANCE IN MATRIX AND VECTOR COURSES AMONG CIVIL ENGINEERING STUDENTS

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Abstract

This study examines how different learning approaches are associated with students' academic performance in the context of engineering mathematics, based on a case study of the Matrix and Vector course. A quantitative correlational research design was used in the study. Data were collected from 101 civil engineering students at Institut Teknologi Padang. Students' learning approaches were measured using a structured questionnaire based on Biggs' theory. Students' academic performance was obtained from the course records in the form of midterm and final exam results. Data were analyzed using descriptive statistics, Pearson correlation, and multiple regression. The results showed that all learning approaches (surface, deep, and achieving) have a significant positive correlation with midterm exam results. However, in the final exam results, only the deep and achieving approaches have a significant positive correlation with the final exam results. Despite the positive correlation found in the study, the multiple regression analysis showed that the learning approaches have no significant predictive relationship with the students' academic performance. Additionally, the results showed a low explanatory power of the model ($R^2 = 0.100$ for the midterm and $R^2 = 0.054$ for the final exam results). These findings suggest that learning approaches are associated with academic performance but have a limited contribution when considered simultaneously. These results highlight that other factors, such as prior knowledge, motivation, and instructional design, may play a more dominant role in shaping students' academic outcomes in engineering mathematics.

Keywords: learning approaches, academic performance, engineering mathematics, matrix and vector, multiple regression

INTRODUCTION

Mathematics plays a fundamental role in engineering education, particularly in civil engineering, because it provides the conceptual and analytical foundation required for solving engineering problems (Pepin et al., 2021; Yusnita & Lovia, 2025). Among the core topics of engineering mathematics, matrices and vectors are particularly important because they support the development of students' analytical reasoning, symbolic thinking, and mathematical problem-solving skills. Nevertheless, previous studies have consistently reported that many students experience difficulties in understanding abstract mathematical concepts, particularly in linear algebra, due to challenges in conceptualizing these concepts (Jäder & Johansson, 2025; Yatri et al., 2025). Taken together, these findings suggest that although mathematics is indispensable in engineering education, improving students' conceptual understanding remains a major challenge that may influence their academic performance.

Academic performance in higher education is influenced not only by students' cognitive ability but also by how they engage in the learning process. One of the most widely studied perspectives explaining this engagement is the concept of learning approaches, which reflects students' motivation, cognitive engagement, and learning strategies. According to Biggs' theory of learning approaches, students adopt different approaches to learning depending on their learning motives and strategies. These approaches are generally categorized into surface, deep, and achieving approaches, each representing a distinct pattern of cognitive engagement and learning behavior (Biggs, 1987).

Surface learning is characterized by memorization and minimum task completion, whereas deep learning emphasizes meaningful understanding and knowledge integration. In contrast, the achieving approach reflects organized study behavior, effective time management, and a strong orientation toward obtaining high academic achievement. These approaches are closely associated with self-regulated learning behaviors, including effective time management, learning strategies, and active participation in learning activities (Maya et al., 2021; Özdal et al., 2022; Yusri et al., 2024). These three learning approaches provide an important theoretical framework for understanding how students engage with mathematically intensive courses and may influence their academic performance. Taken together, these studies indicate that learning approaches represent an important non-cognitive factor that may contribute to students' academic achievement.

Learning approach and academic achievement have been thoroughly researched in previous research. In most cases, learners who use proper learning methods along with high motivation levels have shown improved academic results (Diseth, 2025). Overall, students adopting deep learning approaches tend to demonstrate better academic achievement, whereas surface learning is generally associated with poorer learning outcomes. Nevertheless, empirical findings remain inconsistent across educational settings, with several studies reporting weak or statistically insignificant relationships between learning approaches and academic performance (Angellita et al., 2024; Gabut et al., 2025). These inconsistent findings suggest that the relationship between learning approaches and academic performance may depend on the disciplinary context and learning characteristics of the subject being studied.

Engineering mathematics, particularly Matrix and Vector courses, presents learning characteristics that differ substantially from those of general education courses. Students are required to perform symbolic manipulation, integrate conceptual and procedural knowledge, and solve mathematically complex, multi-step problems. Consequently, academic performance in such courses is influenced not only by students' learning approaches but also by prior mathematical knowledge, analytical reasoning, and higher-order cognitive processes (Malay et al., 2026; Veronika & Anggraini, 2025). Furthermore, contextual learning conditions and behavioral engagement may also contribute to students' academic success. These findings indicate that while learning approaches remain relevant, their influence on academic performance in engineering mathematics may differ from that observed in broader educational contexts.

Although research on learning approaches has expanded considerably over the past decade, most previous studies have been conducted in general educational settings involving students from diverse disciplines. Comparatively fewer studies have examined learning approaches within discipline-specific contexts, particularly engineering mathematics, where learning demands are substantially different from those encountered in general courses (Alam & Mohanty, 2024; Dwita, 2020). As a result, the extent to which learning approaches are associated with academic performance in engineering mathematics remains insufficiently understood. This gap limits the generalizability of previous findings to mathematically intensive engineering courses and highlights the need for discipline-specific empirical evidence.

Therefore, this study intends to explore the association between students’ learning styles (surface, deep and achieving) and academic success in the Matrix and Vector course among civil engineering students. Pearson correlation analysis was used to investigate bivariate correlations between variables. Multiple regression analysis was used to analyse the simultaneous predictive impact of the three learning approaches on academic performance. The findings are expected to contribute empirical evidence regarding the role of learning approaches in engineering mathematics and provide implications for designing more effective learning strategies in mathematically intensive engineering courses.

Based on the literature reviewed, the following hypotheses were formulated.

H1: Surface learning approach is significantly associated with students' academic performance.

H2: Deep learning approach is significantly associated with students' academic performance.

H3: Achieving learning approach is significantly associated with students' academic performance.

H4: Surface, deep, and achieving learning approaches jointly predict students' academic performance.

METHOD

This study employed a quantitative correlational design to examine the relationship between students' learning approaches and their academic performance in the Matrix and Vector course. A correlational research design is commonly used in educational research to investigate the relationship between the learning approaches and the academic performance of the students. This design enables researchers to examine the relationship between variations in learning approaches and variations in students' academic performance (Alimudin, 2025; Kusumastuti et al., 2025).

The participants were civil engineering students studying the course Matrix and Vector in the odd semester of the 2025/2026 academic session at Institut Teknologi Padang (ITP). The population was made up of 101 civil engineering students studying in three different classes: TS-SEM3-A, TS-SEM3-B, and TS-SEM3-C. A total sampling technique was used, meaning that the whole population was used for the study. This method was used because the population was small, thus providing better representation and eliminating sampling bias (Ahmed, 2024; Dede & Firmansyah, 2022).

The study investigated two variables: learning approaches as the independent variable and students' academic performance as the dependent variable. Learning approaches were categorized into surface, deep, and achieving approaches based on Biggs' theory of learning approaches (Biggs, 1987). Academic performance was measured using the midterm and final examination scores obtained from the academic information system.

The measurement instrument was developed by the researchers based on Biggs' theory of learning approaches, which conceptualizes students' learning behavior into three dimensions: surface, deep, and achieving approaches (Biggs, 1987). The instrument was specifically designed to measure students' learning approaches in the context of the Matrix and Vector course in engineering mathematics. The instrument development began by identifying the theoretical indicators representing each learning approach, which were subsequently translated into questionnaire items reflecting learning behaviors commonly encountered in engineering mathematics, including conceptual understanding, symbolic manipulation, procedural problem-solving, and independent learning. A total of 30 items were developed, consisting of 10 items for each construct, to provide adequate representation of the three theoretical dimensions.

To ensure contextual relevance, the questionnaire items were written specifically for learning situations encountered in the Matrix and Vector course rather than using generic higher education learning contexts. The preliminary instrument was then reviewed by two experts in mathematics education to evaluate the relevance, clarity, and representativeness of each item, and revisions were made based on their recommendations before the questionnaire was administered in the pilot study. All questionnaire items employed a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). This response format was selected to reduce neutral responses and encourage respondents to express more definite opinions (Antoro, 2025). The instrument was further evaluated for validity using the corrected item-total correlation method and for reliability using Cronbach's alpha to ensure that it was appropriate for the main data collection.

Academic performance was represented by midterm and final examination scores obtained from the academic information system. These data were obtained from the academic information system to ensure accuracy and objectivity. This approach provides a more comprehensive representation of students' performance compared to relying on a single assessment indicator. Therefore, it allows for a more valid evaluation of academic achievement.

The developed instrument was subsequently tested for validity and reliability. For validity, the corrected item-total correlation method was used. A minimum correlation coefficient of 0.30 was acceptable. However, all the items had a correlation coefficient higher than the minimum requirement. For reliability, Cronbach's alpha was used. High reliability was established for all the constructs, with Cronbach's alpha values of 0.947 for the deep approach, 0.944 for the Achieving approach, and 0.899 for the surface approach, all above the minimum requirement of 0.70.

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 22. Descriptive statistics were used to describe the characteristics of the variables. Then, Pearson correlation was used to investigate the relationship between the learning approaches and the students' academic performance. The correlation was categorized as follows: 0.00-0.19 (very weak correlation), 0.20-0.39 (weak correlation), 0.40-0.59 (moderate correlation), 0.60-0.79 (strong correlation), and 0.80-1.00 (very strong correlation) (Widianingsih et al., 2025). Additionally, multiple regression analysis was used to investigate the simultaneous effect of surface, deep, and achieving approaches on the students' academic performance (Astika & Sumakul, 2020; Pisică et al., 2022). The regression model is expressed as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

where:
Y denotes students' academic performance;
X_1 denotes surface approach;
X_2 denotes deep approach;
X_3 denotes achieving approach;
β_0 denotes the intercept;
β_1, β_2, and β_3 denotes the regression coefficients;
ε denotes the error term.

Participation in the study was voluntary, and the respondents were made aware of the purpose of the study before the actual research was conducted. Confidentiality was also ensured in the responses collected by the researcher. This ensured that ethical standards were maintained.

RESULTS AND DISCUSSION

This section will present the results of the statistical analysis carried out to determine the association between learning approaches and academic performance for the students in the course on Matrix and Vector. The statistical analysis carried out on the data includes descriptive statistics, Pearson correlation analysis, and multiple regression analysis.

Descriptive Statistics

Descriptive statistics were first conducted to summarize the distribution of all study variables, including the three learning approaches (surface, deep, and achieving) and students' academic performance measured by the midterm and final examination scores. The descriptive measures included the minimum, maximum, mean, and standard deviation, providing an overview of the respondents' characteristics before conducting the correlation and regression analyses. The results are presented in Table 1.

Table 1. Descriptive Statistics of Study Variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Surface Approach	101	10	40	24.9	5.28
Deep Approach	101	10	40	30.8	5.19
Achieving Approach	101	10	40	31.5	4.89
Midterm Exam	101	30	100	64.70	20.33
Final Exam	101	57	94	72.10	8.76

The descriptive statistics presented in Table 1 provide an overview of the distribution of the study variables. Among the three learning approaches, the highest mean score was observed for the achieving approach (M = 31.5, SD = 4.89), followed by the deep approach (M = 30.8, SD = 5.19), whereas the surface approach had the lowest mean score (M = 24.9, SD = 5.28). Regarding academic performance, the mean midterm examination score (M = 64.7, SD = 20.3) was lower than the mean final examination score (M = 72.1, SD = 8.76). In addition, the larger standard deviation and wider score range observed in the midterm examination indicate greater variability in students' performance compared with the final examination.

Overall, the descriptive statistics suggest that the respondents tended to report higher levels of deep and achieving learning approaches than surface learning. Furthermore, students' performance in the final examination was characterized by a higher average score and lower variability than in the midterm examination. These descriptive findings provide an initial overview of the study variables before the correlation and regression analyses.

Pearson Correlation Analysis

To examine the degree of association between learning approaches and academic performance, Pearson correlation analysis was conducted. This analysis aims to identify both the direction and strength of the relationships between variables. The results of the correlation analysis are presented in Table 2.

Table 2. Pearson Correlation between Learning Approaches and Academic Performance

Learning Approach	Midterm Examination *r*	*p*-value	Final Examination *r*	*p*-value
Surface Approach	0.246	0.013*	0.117	0.245
Deep Approach	0.268	0.007*	0.220	0.027*
Achieving Approach	0.276	0.005*	0.217	0.030*

Note: r = Pearson correlation coefficient. $p < 0.05$ indicates statistical significance.

As depicted in Table 2, all three learning approaches, surface, deep, and achieving, have been found to be positively and significantly related to midterm exam performance. This is indicated by surface approach ($r = 0.246$, $p = 0.013$), deep approach ($r = 0.268$, $p = 0.007$), and achieving approach ($r = 0.276$, $p = 0.005$). However, the case is different from the results obtained from the final exam performance. It is found that only deep approach ($r = 0.220$, $p = 0.027$) and achieving approach ($r = 0.217$, $p = 0.030$) have been found to be positively and significantly related to academic performance, while surface approach is not significant ($r = 0.117$, $p = 0.245$).

Overall, although several learning

approaches show statistically significant correlations with academic performance, the strength of these relationships remains relatively weak. These results highlight that learning approaches may contribute to students' performance to some extent, but they are unlikely to function as strong independent predictors. Therefore, further analysis using multiple regression is necessary to examine whether these variables can jointly explain students' academic outcomes.

Multiple Regression Analysis

To further investigate whether learning approaches can jointly predict academic performance, a multiple regression analysis was performed. This analysis evaluates the simultaneous effect of surface, deep, and achieving approaches on students' academic outcomes. The results of the regression analysis are presented in Table 3.

Midterm Exam

A multiple regression analysis was performed to assess whether surface, deep, and achieving approaches significantly predict students' midterm exam performance. The results of this analysis are presented in Table 3.

Table 3. Regression Results for Midterm Exam

Variable	*B*	SE	*t*	Sig. (*p*)
Intercept	20.658	13.669	1.511	0.134
Surface Approach	0.546	0.419	1.302	0.196
Deep Approach	0.459	0.572	0.803	0.424
Achieving Approach	0.515	0.621	0.829	0.409

The regression results show that the model has a poor explanatory capability, with an R^2 value of 0.100, indicating that only 10% of the variation in the midterm exam score can be explained by the three learning approaches. Table 3 shows that the individual predictors are not statistically significant. This indicates that while the learning approaches have a significant correlation with the midterm exam score, they have a weak combined effect in the regression model.

Final Exam

A similar regression analysis was conducted to examine the predictive influence of learning approaches on final exam performance. The results are summarized in Table 4.

Table 4. Regression Results for Final Exam

Variable	*B*	SE	*t*	Sig. (*p*)
Intercept	58.419	6.036	9.679	< 0.001
Surface Approach	0.019	0.185	0.103	0.918
Deep Approach	0.219	0.252	0.868	0.387
Achieving Approach	0.205	0.274	0.747	0.457

The regression results show that the model accounts for only 5.4% of the variance in final exam scores ($R^2 = 0.054$), indicating a weak predictive relationship. As indicated in Table 4, none of the learning approaches has a statistically significant predictive effect on the final exam scores. This indicates that students' final exam performance is influenced by factors beyond learning approaches. These results indicate that the learning approach is not the key determinant of academic performance.

Overall, the regression analysis consistently shows that the predictive power of the learning approaches on students' academic performance is limited. Although these variables show significant relationships at the bivariate level, they do not demonstrate strong explanatory power when analyzed jointly. This indicates that academic performance is influenced by multiple factors beyond learning approaches. From the perspective of Biggs' learning approaches theory, this finding suggests that learning approaches represent only one dimension of students' learning behavior and are not sufficient to independently explain academic achievement. In engineering mathematics, students' performance is also likely to depend on prior mathematical knowledge, conceptual understanding, and analytical problem-solving skills. Therefore, learning approaches should be interpreted as complementary rather than dominant determinants of academic performance in mathematically intensive courses.

Discussion

The findings of the present study indicate that learning approaches have a limited association with students' academic performance in the Matrix and Vector course. The Pearson correlation analysis showed that all three learning approaches were significantly associated with midterm examination performance, whereas only deep and achieving approaches remained significantly associated with final examination performance. These findings are consistent with previous studies reporting that deep learning approaches are generally associated with better academic achievement, whereas surface learning tends to show weaker relationships. However, several studies have also reported inconsistent or insignificant relationships, suggesting that the influence of learning approaches varies across educational contexts and disciplines (Angellita et al., 2024; Gabut et al., 2025; Zhong et al., 2023). While previous studies conducted in general educational settings generally reported stronger relationships between deep learning approaches and academic achievement, the present study found only weak correlations and non-significant regression effects. Taken together, these findings indicate that the influence of learning approaches is context-dependent and becomes less dominant in mathematically intensive engineering courses, where domain-specific cognitive competencies play a more substantial role. This finding supports the need for discipline-specific investigations because relationships observed in general educational settings may not be directly transferable to mathematically intensive engineering courses.

Although significant correlations were observed, the multiple regression analysis showed that none of the learning approaches significantly predicted academic performance. This difference can be explained by the different purposes of the two statistical techniques. Pearson correlation evaluates the relationship between two variables independently, whereas multiple regression estimates the unique contribution of each predictor after controlling for the others. Consequently, learning approaches may demonstrate significant bivariate relationships with academic performance but provide limited unique explanatory power when analyzed simultaneously.

The low coefficient of determination further suggests that students' academic performance is influenced by factors beyond learning approaches. Previous studies have shown that prior mathematical knowledge, conceptual understanding, analytical reasoning, motivation, self-regulated learning, and instructional quality contribute substantially to achievement in mathematics-related courses (Wolters & Brady, 2021; Pepin et al., 2021; Wild & Neef, 2023). Therefore, academic performance in engineering mathematics should be viewed as the result of multiple interacting cognitive and contextual factors rather than learning approaches alone.

From a pedagogical perspective, engineering mathematics instruction should not only encourage effective learning approaches but also strengthen students' conceptual understanding and mathematical problem-solving skills. Learning activities such as guided problem solving, formative assessment, contextual engineering examples, and early diagnostic assessment may help improve students' readiness for mathematically intensive courses. Future studies are also encouraged to include additional variables, such as prior knowledge, motivation, and self-efficacy, to obtain a more comprehensive understanding of academic performance.

CONCLUSION

This study examined the association and predictive contribution of learning approaches (surface, deep, and achieving) to academic performance in the Matrix and Vector courses. The results showed that learning approaches are significantly related to midterm exam performance, while only deep and achieving approaches are significant to final exam performance. However, these relationships are relatively weak. This implies that learning approaches are associated with academic performance but provide limited predictive contribution when considered simultaneously. Moreover, based on the results of multiple regression analysis, learning approaches do not have significant predictive power on academic performance. This implies that learning approaches have a small contribution to academic performance as indicated by a low coefficient of determination. This suggests that other factors may play a more dominant role in academic performance.

These results indicate the importance of the fact that the performance in mathematically intensive subjects might be more affected by domain-specific skills, such as prior knowledge, cognitive skills, and problem-solving skills, than by learning approaches in general. Hence, while facilitating deeper learning and learning in general remain crucial, such approaches might not be effective as a main factor in predicting students' academic performance. For further research, it is recommended to add other factors such as motivation, prior knowledge, and teaching methods to offer a more complete account of the factors affecting students' academic performance. From a practical perspective, engineering mathematics instructors should integrate learning strategies that promote deep understanding with activities that strengthen students' conceptual and problem-solving abilities. The present study contributes to the limited literature on learning approaches in engineering mathematics by providing empirical evidence from a discipline-specific context.

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