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Identifying the Level of Mastery of Basic Engineering Calculations among Diploma in Civil Engineering Students at POLIMAS

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Abstract−This study aims to identify the level of mastery of basic engineering calculations among Diploma in Civil Engineering students at POLIMAS. In addition, the study seeks to determine the factors influencing students' weaknesses in basic calculations and to propose improvement strategies to enhance their calculation skills. A quantitative approach was employed using a survey method through the distribution of questionnaires to 82 Diploma in Civil Engineering students as research respondents. The data obtained were analysed using IBM SPSS Statistics, involving descriptive statistical analyses such as mean, standard deviation, frequency, and percentage. A reliability test of the instrument was conducted using Cronbach's Alpha, which yielded a value of 0.963, indicating a very high level of internal consistency. The findings reveal that the overall level of mastery of basic engineering calculations among students is high, with an overall mean score of 3.97. However, several weaknesses were identified, including difficulties in identifying calculation errors, lack of self-confidence, and weaknesses in applying appropriate mathematical formulas. The study also found that weaknesses in mathematical foundations stem from insufficient continuous practice and less interactive learning approaches, which affect students' mastery of basic skills. To enhance basic calculation skills, several improvement strategies are proposed, including the implementation of basic calculation workshops, the use of interactive learning modules, continuous practice, and additional consultation sessions with lecturers. In conclusion, mastery of basic engineering calculations is a crucial element in ensuring students' academic excellence in the field of engineering. Therefore, continuous efforts from institutions, lecturers, and students are necessary to strengthen basic engineering calculation skills among polytechnic students.

Keywords: Mastery of Basic Calculations; Engineering Mathematics; Diploma Students; Mathematics Learning Difficulties; TVET Education

1. INTRODUCTION

Mastery of basic engineering calculation skills is a fundamental element in ensuring the effectiveness of the learning process among diploma-level Civil Engineering students. These skills encompass the ability to apply basic mathematical operations, algebraic concepts, and calculus principles effectively in addressing authentic, application-oriented engineering problems. According to the Ministry of Education Malaysia (2023), strong mathematical proficiency forms the foundation for students' engagement and success in STEM fields, including engineering. Therefore, weaknesses in mastering basic calculations may have significant implications for students' ability to cope with more advanced technical courses, such as mechanics and structural analysis.

Nevertheless, various studies indicate that engineering students continue to face considerable challenges in mastering fundamental mathematics. A study by Rozita Kadar et al. (2023) found that students frequently experience weaknesses in algebraic manipulation and conceptual understanding, which in turn affect their ability to solve technical problems. Similarly, Rahmiaty et al. (2023) reported that algebra mastery among technical students remains at a moderate level, reflecting a notable gap between theoretical knowledge and practical engineering applications.

From the perspective of difficulty levels, research shows that topics requiring higher-order thinking skills such as calculus, step-by-step problem-solving, and the application of formulas in real-world contexts are among the most challenging areas. Asshaari et al. (2024) found that students continue to struggle with mastering vector calculus concepts despite having received formal instruction. These findings suggest that traditional teaching approaches may be less effective in fostering deeper conceptual understanding, particularly when applied within the context of engineering education.

In addition, factors influencing weaknesses in mastering basic engineering calculations have been identified across cognitive, affective, and pedagogical dimensions. Kaharudin et al. (2024) found that learning strategies, motivation, and students' attitudes toward mathematics significantly affect their academic achievement. Furthermore, Sohimi et al. (2022) emphasized that the learning environment and instructional approaches also play an important role in determining students' mastery levels in technical fields.

Finally, the relationship between mastery of basic calculations and academic performance among engineering students has been consistently supported by previous studies. In line with the findings of Awang and Othman (2024), students who participated in mathematics reinforcement interventions demonstrated significant improvement in their academic performance. Therefore, this study is crucial in identifying students' mastery levels, determining the types of difficulties they encounter, and examining the contributing factors to these weaknesses, so that more effective interventions can be designed to enhance the quality of engineering education in polytechnics.

Mastery of basic calculations is a crucial prerequisite in engineering education. However, some Diploma in Civil Engineering students have been found to experience difficulties in solving fundamental calculation problems involving

algebraic operations, formula manipulation, and the application of trigonometry. These challenges may hinder their understanding of more advanced engineering subjects and negatively affect their overall academic performance.

Recent studies emphasize that mastery of fundamental mathematics is a critical prerequisite for students' success in engineering, particularly in courses that require handling more complex calculations such as calculus and technical analysis. A study by Siti Asmah Mohamed et al. (2024) found that mathematics courses are core subjects that must be passed, and failure in these courses directly affects students' overall academic performance. This indicates that mastery of basic calculations is not merely a supporting skill but a critical factor in determining engineering students' academic success.

Research findings also indicate that weaknesses in mathematical foundations have a continuous impact on students' performance in advanced engineering courses. A study conducted in polytechnics by Mohd Radhi Musa et al. (2024) found a significant positive relationship between achievement in early Engineering Mathematics courses and performance in advanced courses. This suggests that students who are weak in basic calculations at the early stages are more likely to experience ongoing difficulties in more complex subjects.

In addition, the types of calculations most difficult for students to master include advanced algebra, calculus, and multi-step problem-solving. Studies suggest that these difficulties stem from students' inability to connect theoretical concepts with real-world engineering applications. In this context, mathematics requires not only conceptual understanding but also cognitive abilities to analyse and systematically solve problems. The lack of such skills makes it difficult for students to master more complex technical courses.

Furthermore, these weaknesses are influenced by broader systemic issues in mathematics education. Current reports indicate that a significant proportion of students in Malaysia have not fully mastered basic mathematical skills, including fundamental operations and logical reasoning. For instance, nearly one-quarter of students fail mathematics at the SPM level (RTM, November 2021), reflecting foundational weaknesses before entering higher education. This situation indirectly affects students' readiness to undertake engineering mathematics courses at the polytechnic level.

Finally, previous studies consistently confirm a significant relationship between mastery of basic calculations and academic performance among engineering students. Students with strong mathematical foundations are better able to understand complex engineering concepts and achieve higher academic results. Conversely, students who are weak in basic calculations tend to face persistent difficulties across various technical courses. Therefore, research findings highlight the need for early interventions such as mathematics reinforcement programs, active learning approaches, and the integration of technology in teaching to comprehensively enhance students' mastery levels.

A weak mathematical foundation is a primary factor contributing to students' difficulties in engineering education. A study by Setiawan et al. (2024) found that secondary school mathematics achievement is significantly related to students' performance in engineering mathematics courses. This indicates that students without a strong foundational background are more likely to struggle at higher levels of education.

Mathematics anxiety also affects students' academic performance. Ozturk et al. (2025) found that students with high levels of mathematics anxiety tend to demonstrate lower performance in solving calculation-related problems. Anxiety reduces concentration, confidence, and problem-solving effectiveness.

Students' attitudes and motivation toward mathematics play an important role in determining their level of mastery. A report by RTM News (2024) indicated that a lack of interest in mathematics among polytechnic students is one of the main causes of weaknesses in applying basic calculations. Negative attitudes reduce students' effort and willingness to understand mathematical concepts, ultimately affecting their academic achievement.

2. RESEARCH METHODS

2.1 Research Design

This study adopts a quantitative approach using a descriptive survey design. This approach was selected as it is appropriate for identifying the level of mastery of basic engineering calculations, the factors influencing students' weaknesses in basic calculations, and proposing improvement strategies to enhance students' calculation skills. A survey method using questionnaires was employed to obtain data directly from respondents. The quantitative method enables systematic and objective data analysis through statistical procedures.

2.2 Research Location

The study was conducted at Polytechnic of Sultan Abdul Halim Mu'adzam Shah (POLIMAS), Jitra, involving students from the Diploma in Civil Engineering program.

2.3 Population and Sample

The population of this study consisted of Diploma in Civil Engineering students at Polytechnic of Sultan Abdul Halim Mu'adzam Shah, Jitra. The sample comprised 82 students selected using a simple random sampling technique. The selection method ensured that each student had an equal opportunity to be chosen as a respondent. This technique is appropriate as it minimizes bias in respondent selection.

2.4 Article Selection Process

The primary research instrument was a questionnaire developed based on the research objectives and previous studies related to mathematics mastery and basic engineering calculations.

Table 1. The Questionnaire Was Divided Into Two Part

Section	Content
Section A	Respondents' demographic information
Section B	Level of Mastery of Basic Mathematical Calculations

Table 2. The Instrument Utilized A Five-Point Likert Scale

Score	Level of Agreement
1	Strongly Dissagree
2	Dissagree
3	Neutral
4	Agree
5	Strongly Agree

2.5 Pilot Study

A pilot study was conducted to determine the reliability of the questionnaire instrument before the actual study was carried out. Reliability testing was performed using Cronbach's Alpha analysis through IBM SPSS Statistics. The results showed that the Cronbach's Alpha value for the instrument was 0.963. This value indicates that the instrument has a very high level of reliability and is suitable for use in the actual study. According to Joseph F. Hair, a Cronbach's Alpha value exceeding 0.70 indicates good reliability.

2.6 Data Collection and Procedure

The data collection process was conducted in stages. The researcher first obtained permission from the relevant authorities before distributing the questionnaire to respondents via a Google Form link. The questionnaire was distributed to Diploma in Civil Engineering students, and respondents were given a specific period to complete it. All information obtained was used solely for academic and research purposes.

2.7 Data Analysis Method

The collected data were analysed using the latest version of IBM SPSS Statistics. Descriptive statistical analysis was employed to present the data in the form of frequency, percentage, mean, and standard deviation.

Table 3. The Analysis Methods Used Based on The Research Objectives

Research Objectives	Method of Analysis
To identify the level of mastery of basic engineering calculations	Mean and standard deviation
To identify factors influencing weaknesses in basic calculations	Descriptive analysis
To identify improvement strategies	Mean analysis and ranking

Table 4. The Interpretation of Mean Scores

Mean Range	Interpretation
1.00-2.33	Low
2.34-3.66	Moderate
3.67-5.00	High

2.8 Research Ethics

The researcher ensured that all respondents' information remained confidential and was used solely for research purposes. Respondents were also informed about the purpose of the study before completing the questionnaire.

3. RESULTS AND DISCUSSION

3.1 Data and Analysis

A total of 82 Diploma in Civil Engineering students at POLIMAS participated in this study. Data analysis was conducted using IBM SPSS Statistics, involving descriptive analysis and reliability testing.

3.1.1 Instrument Reliability Test

Reliability testing was conducted using the Cronbach's Alpha method to ensure that the questionnaire items demonstrated good internal consistency.

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Table 5. Reliability Test Result

Constuct	Number of Items	Chronbach's Alpha Value	Interpretation
Mastery of Basic Mathematical Calculations	10	0.963	Very Good

Based on the analysis conducted, the Cronbach's Alpha value obtained was 0.963. This value indicates that the research instrument has a very high level of reliability and is suitable for use in the actual study.

3.2 Analysis of the Level of Mastery

Table 6. Level of Mastery

Item	Mean	Standard Deviation	Interpretation
B1	4.02	0.79	High
B2	4.00	0.77	High
B3	3.93	0.78	High
B4	4.02	0.85	High
B5	4.01	0.81	High
B6	4.07	0.77	High
B7	3.98	0.79	High
B8	3.87	0.79	High
B9	3.88	0.80	High
B10	3.95	0.82	High

Overall Mean: 3.97

Based on the descriptive analysis, the overall mean score for the level of mastery of basic engineering calculations is 3.97, indicating that students' mastery level is high. The item with the highest mean score was:
B6: Ability to read and interpret graphs (Mean = 4.07) The item with the lowest mean score was:
B8: Ability to identify common calculation errors (Mean = 3.87)

These findings indicate that most students possess a good level of mastery in basic engineering calculations. However, some students are still less proficient in identifying errors during the calculation process.

3.3 Analysis of Factors Influencing Weaknesses in Basic Calculations

Based on the analysed questionnaire items, several factors were identified as influencing students' weaknesses in basic calculations:

Table 7. Influencing Weaknesses in Basic Calculations

Factor	Description
Weak mathematical foundation	Students still face difficulties in understanding basic mathematical concepts and certain calculations
Lack of confidence	Some students lack confidence when solving engineering calculation problems
Difficulty identifying errors	Students are less skilled in detecting mistakes during the calculation process
Use of formulas	Students experience difficulty in selecting and applying appropriate formulas
Lack of additional practice	Not all students consistently engage in additional exercises or revision

Although the overall mastery level is high, the analysis shows that several weaknesses still affect students' basic calculation skills. The main factors include difficulty in identifying errors during calculations, lack of self-confidence, and insufficient continuous practice.

3.4 Proposed Improvement Strategies to Enhance Students' Basic Skills

Based on the research findings, several improvement strategies are proposed to enhance students' basic calculation skills:

Table 8. Strategies to Enhance Students' Basic Skills

Recommendation	Description
Basic Calculation Workshops	Organizing intensive workshops on engineering calculations and problem-solving
Continuous Practice	Providing regular exercises to strengthen calculation skills
Use of Interactive Modules	Implementing digital modules or gamification in engineering mathematics learning
Strengthening Mathematical Foundation	Conducting reinforcement classes for students weak in basic mathematics
Problem-Based Learning	Applying real-world problem-based approaches to enhance conceptual

Recommendation	Description
	Understanding
Lecturer Guidance	Providing additional consultation and tutorial sessions for students

These proposed improvement strategies are expected to effectively enhance students' mastery of basic calculations. Continuous practice and interactive learning approaches are anticipated to improve both students' understanding and confidence in solving engineering calculation problems.

3.5 Discussion

The discussion of this study is structured based on the three main research objectives: identifying the level of mastery of basic engineering calculations among Diploma in Civil Engineering students at POLIMAS, determining the factors influencing students' weaknesses in basic calculations, and proposing improvement strategies to enhance students' basic calculation skills.

Regarding the first objective, the findings indicate that the level of mastery of basic engineering calculations among students is high, with an overall mean score of 3.97. This finding suggests that most students possess a good understanding of fundamental mathematical and engineering calculation concepts, including the use of formulas, unit calculations, graph interpretation, and basic engineering problem-solving.

However, several items recorded slightly lower mean scores, particularly in the aspect of identifying calculation errors. This finding indicates that some students are still less meticulous during the calculation and technical problem-solving process. Such weaknesses may affect students' academic performance, especially in courses involving complex calculations such as structural mechanics, geotechnics, and hydraulics, which require high levels of accuracy and computational understanding.

These findings are consistent with the view of Joseph F. Hair, who emphasizes that strong mastery of basic mathematics enables students to better understand technical and analytical learning. In addition, a study by Mohd Radhi Ibrahim found that weaknesses in mathematical foundations are among the primary factors influencing engineering students' academic achievement in higher education institutions. Students who do not master fundamental calculation skills tend to face difficulties in understanding engineering concepts and solving more complex computational problems.

Regarding the second objective, the study identified several factors influencing students' weaknesses in basic calculations. The main factors include weak mathematical foundations, lack of self-confidence, difficulty in selecting appropriate formulas, and insufficient consistent practice.

Weak mathematical foundations significantly affect students' ability to understand more complex engineering concepts. Students who do not master basic mathematical operations such as algebra, fractions, ratios, and equations are found to struggle more in solving engineering calculation problems. Additionally, self-confidence plays an important role in students' performance, as those with lower confidence levels tend to avoid engaging in calculation exercises and are less active during learning sessions.

The study also shows that teaching approaches play a crucial role in enhancing students' mastery of basic calculations. Learning methods that are overly theory-oriented without sufficient practical exercises may hinder students' understanding of real-world engineering applications. Therefore, the use of interactive learning approaches such as problem-based learning, gamification, and calculation simulations can help improve students' understanding more effectively.

For the third objective, several improvement strategies were identified to enhance students' basic calculation skills. These include the implementation of basic calculation workshops, the provision of mathematics reinforcement modules, continuous practice, and the integration of technology and interactive learning materials.

The regular implementation of basic calculation workshops can help students strengthen their understanding of engineering calculation concepts through practical exercises and real-world problem-solving activities. Furthermore, the use of interactive modules and gamification in learning is expected to increase students' interest and motivation in studying mathematics and engineering calculations.

In addition, lecturer support through additional guidance and consultation sessions is essential to assist students who are weak in basic calculations. A focused and step-by-step learning approach can help students build confidence and improve their problem-solving skills more effectively.

Overall, the findings of this study demonstrate that mastery of basic engineering calculations is a crucial element in ensuring the academic success of Diploma in Civil Engineering students. Therefore, all stakeholders including lecturers, institutions, and students must play an active role in strengthening mathematical foundations and engineering calculation skills to enhance academic performance and professional competency in the field of engineering.

4. CONCLUSION

Overall, this study successfully achieved all three research objectives related to the mastery of basic engineering calculations among Diploma in Civil Engineering students at POLIMAS. The findings indicate that the level of students' mastery of basic calculations is high, based on the overall mean score obtained through descriptive analysis using IBM SPSS Statistics. Although most students demonstrated good mastery in basic calculation skills, the study also identified several weaknesses that require attention, particularly in identifying calculation errors, applying appropriate formulas

accurately, and students' confidence levels when solving engineering calculation problems. Factors such as weak mathematical foundations, lack of continuous practice, and less interactive teaching approaches were identified as contributing to these issues. Among the proposed improvement strategies are the implementation of basic calculation workshops, the use of interactive learning modules, regular calculation exercises, and additional guidance sessions conducted by lecturers. A more active and student-cantered learning approach is expected to enhance students' interest, motivation, and confidence in engineering calculations. Furthermore, this study is expected to serve as a reference for institutions, lecturers, and researchers in designing more effective learning strategies to enhance students' mastery of basic engineering calculations at polytechnics. Future research is recommended to involve a larger sample size and to employ more diverse research approaches, such as mixed-method designs, to obtain more comprehensive findings. In conclusion, mastery of basic engineering calculations is a crucial element in ensuring students' academic excellence and professional competency in the field of engineering. Therefore, collaboration among all stakeholders is essential to ensure that students can strengthen their fundamental calculation skills and subsequently improve the quality of technical and engineering education in the country.

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