Analysis of Summative Pre-Calculus Assessment for Computer Science Students

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ABSTRACT

In foundational courses like Pre-Calculus, summative assessment is a common method to evaluate student learning in mathematics. Many students were seen struggling to pass the Pre-Calculus course, especially students with an inadequate SPM-level mathematics. Although educators are aware of the challenges faced by these students, few studies have investigated their performance patterns in the summative assessment. This study aims to analyse students' performance in the Pre-Calculus summative assessment by examining the distribution of marks and the questions students choose to attempt. The summative assessment is an individual written final examination comprising 25 questions on various topics in this course. Data from the answer scripts of 32 repeat students were collected and analysed using descriptive analysis. Results show that all students attempted questions on inequalities, complex numbers, and systems of linear equations, with the median scores being higher than the average scores. Conversely, students performed poorly on questions on trigonometry, suggesting that the topic is challenging. Despite the limited sample size and scope, this study lays the groundwork for curriculum assessment in the Pre-calculus course. More broadly, this move helps to strengthen mathematical learning and contribute to the ove 335-343. rall improvement of STEM education.

Keywords: Mathematics education, Pre-calculus course, Summative assessment, STEM education

INTRODUCTION

Summative assessment is one of the main tools in higher education used to evaluate students' learning and achievement at the end of the semester. In mathematics education, the closed-book final examination remains the traditional way to measure students' ability to recall and apply mathematical procedures to solve problems (Iannone & Simpson, 2022). For Computer Science students, the Pre-Calculus course is the algebraic and analytical prerequisite for later courses such as Calculus, Discrete Mathematics, and Linear Algebra. However, many students faced difficulties in the Pre-Calculus course, which can hinder their progress in other courses within the Computer Science programme. Therefore, analysis of students' performance in summative assessment is vital, especially for students who repeat the course.

Previous research on mathematics assessment in higher education has reported varied findings on students' performance in acquiring mathematical skills (Nortvedt & Buchholtz, 2018). Some studies have also explored teaching strategies towards improving students' performance and learning experience in mathematics. Despite these insights, few studies have been conducted on how repeat students perform in Pre-Calculus summative assessment within Computer Science programmes. It is essential to analyse the summative assessment, for example, the final examination data, because it can reveal students' cumulative understanding at the end of the semester. Furthermore, summative assessments are usually the only standardised evaluation method across all cohorts over time (Iannone & Simpson, 2022). By analysing the distribution of marks based on topics, educators can better understand students' strengths and weaknesses in learning mathematical skills.

Based on the mixed evidence in previous studies, this study focuses explicitly on the summative assessment component to identify student performance at the topic level. Although formative assessments are needed to monitor ongoing students' learning progress, this research is a preliminary investigation to develop a baseline

understanding of how students attempt and perform based on different mathematical topics. By concentrating on the final examination data, the findings are expected to form subsequent future works to understand the factors of mathematical anxiety among students. Moreover, the analysis will also give valuable insights into developing assessment designs and teaching strategies. This detailed understanding is essential in Malaysian tertiary education, where many students enrolling for science-based programs frequently exhibit varying levels of preparedness stemming from their SPM-level mathematics education.

This article is organised as follows. Section 2 provides the literature review on the trend of mathematics performance in secondary schools, the contributing factors and methods proposed to analyse students' performance. Next, Section 3 explains the methodology and data used in this study. The results are discussed in Section 4. Finally, Section 5 presents the conclusion and future research direction.

LITERATURE REVIEW

Trend in Mathematics Performance in Secondary Level Education

Several studies have reported a worrying decline in students' mathematics performance in secondary school. According to the international assessments, Trends in International Mathematics and Science Study (TIMSS), Malaysia's ranking decreased from 1999 to 2007 (Ismail & Awang, 2012). Results from the 2022 Programme for International Student Assessment (PISA) also reported poor performance among Malaysian students, with a lower ranking than other ASEAN counterparts (Ling & Krishnasamy, 2023). The findings by Wei et al. (2025) revealed that over 50% of Malaysian students have poor basic mathematics proficiency. These findings showed the challenging role of educators in teaching mathematics to ensure that students can gain basic mathematical knowledge. Poor mathematics performance among secondary school students will negatively affect university intake, especially in STEM-related fields (Idris, 2006).

Factors Influencing Mathematics Performance

Many studies reported several key factors contributing to poor mathematics performance among undergraduate students. Math anxiety is one of the psychological factors affecting students' confidence and problem-solving efficiency (Omar et al., 2022; Khoo et al., 2024). High levels of math anxiety are consistently associated with poor mathematics performance at the secondary school level (Zakaria et al., 2012; Buratta et al., 2019). Other studies also found that cognitive factors such as a weak mathematical background (Lishchynska et al., 2023) and students' inadequate learning initiative (Sergejeva & Zeidmane, 2023) significantly contribute to undergraduates' mathematics performance. While in Malaysia, findings revealed challenges in teaching quality, the type of pre-university education background and language usage influence students' performance in mathematical courses (Abdullah et al., 2025; Kamal et al., 2015).

Methods in the Analysis of Students' Performance in Mathematics

Several statistical methods are commonly employed to analyse mathematics assessments for undergraduate students. These methods help understand various factors influencing student performance and improve assessment techniques. Descriptive statistics summarise students' performance based on average scores, distribution of marks and pass rate, which can help educators identify areas that are challenging for students. Additionally, descriptive techniques are used to analyse teachers' perceptions of assessment approaches in teaching mathematics (Dogan, 2011). Regression, cluster and factor analysis have also been used to identify the relationship between students' satisfaction and teaching quality that influences their performance (Kuznetsova, 2019). In a study conducted by Adnan et al. (2011), multiple linear regression was used to predict students' performance in mathematics and statistics courses.

METHODOLOGY

This study uses an exploratory research approach to comprehend and investigate the question-answering patterns for the Pre-Calculus course among university students. All 32 students who had registered for this course were involved as participants in this study. These students were in the second year of the Diploma in

Computer Science program and were taking this course for the second time. Students enrolling in the Pre-Calculus course should have a solid foundation in mathematics. Based on the Malaysian Certificate of Education (SPM) results, all these students passed the mathematics subjects, with 10 receiving grades A and A-. In addition, out of all the students, only six took Additional Mathematics during the SPM examination, with only three passing.

The Pre-Calculus course consists of four chapters, namely Coordinates, Graphs and Lines (Chapter 1), Functions (Chapter 2), Systems of Equations and Inequalities (Chapter 3) and Trigonometry (Chapter 4). Chapter 1 introduces fundamental mathematical concepts for pre-calculus, including the real number system, inequalities, absolute value, complex numbers, the Cartesian coordinate plane, graphing, and analytic geometry. Chapter 2 explores functions in mathematics, introducing definitions, properties, and operations. Students learn to solve complex equations and transform graphs for visualisation. On the other hand, Chapter 3 focuses on trigonometry, introducing circular measure, fundamental ratios, graphing functions, identities, and solving equations. It equips students with analytical tools for advanced mathematics, physics, and engineering. Finally, Chapter 4 teaches students how to solve systems of equations and inequalities, enabling them to analyse complex problems involving multiple relationships or constraints.

The summative assessment for the Pre-Calculus course used in this study is taken from the final examination conducted at the end of the semester. The assessment consists of 25 short-answer questions drawn from the four chapters altogether. Table 1 provides information on the chapter and topic for each question.

Table 1. Chapters and topics for each question in the Pre-Calculus final examination paper

Question	Chapter	Topic
1	1 (Coordinates, Lines and Graphs)	Solving inequalities: Quadratic
2		Solving inequalities: Linear
3		Solving inequalities: Absolute Value
4		Complex Number
5		Plane Analytic Geometry: Lines
6		Plane Analytic Geometry: Parabola
7		Plane Analytic Geometry: Circle
8	2 (Functions)	Domain and Range of Function
9		Inverse Function
10		Composite Function
11		Long Division
12		Solving Exponential Equation
13		Transformation of Graph
14	3 (Systems of Equations and Inequalities)	System of Linear Equations
15		System of Nonlinear Equations
16		Solving Systems of Inequalities by Graphing Techniques
17	4 (Trigonometry)	Solution of Trigonometric Equation
18		Circular Measure: Angle
19		Circular Measure: Arc Length

20		Circular Measure: Sector Area
21		Graph of Trigonometric Function
22		Six trigonometric ratios and trigonometric identities
23		Six trigonometric ratios and trigonometric identities
24		Solution of Triangle: Heron's Formula
25		Solution of Triangle: Area

According to Table 1, 28% of the 25 questions were drawn from Chapter 1, 24% from Chapter 2, 12% from Chapter 3 and the rest from Chapter 4. The marks for each question ranged from 2 to 5 marks, with a total of 100 marks. The assessment score is calculated and then classified into four different achievement levels as stated in Table 2.

Table 2. Level of Achievement

Marks	Level of Achievement
Above 70	Excellent
50-69	Good
30-49	Average
Below 30	Weak

Students were given three hours to answer all questions in the final examination. Data were collected based on the students' answer scripts, which were then analysed by the examiner. The marks scored for each question were recorded for every student. Questions that were left blank, without any written answer, are considered "not attempted" by students. Descriptive analysis is then used to analyse the data, which includes tabulation, graphical representation, and the average and median marks scored by the students.

RESULTS AND DISCUSSION

The study includes 32 students, 56.25% male and the rest female. Students were given a set of assessments consisting of 25 short-answer questions with a total mark of 100 covering various topics from four chapters in the Pre-calculus course. Figure 1 depicts the distribution of total summative assessment scores among students.

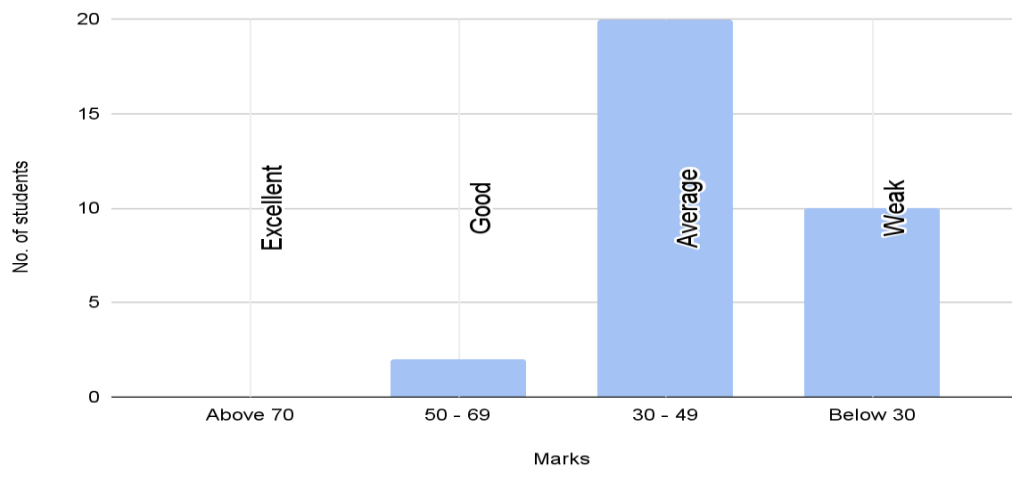

Figure 1. Distribution of total summative assessment scores among students

Based on Figure 1, the majority of students scored between 30 and 49 marks, with no students scoring 70 or above. This finding shows that most students were at an average level of achievement on the assessment given. The details for each question in the summative assessment and its distribution of attempts are shown in Table 3.

Based on Table 3, the results indicate that all students attempted to answer Questions 1 (solving inequalities (quadratic)), Question 2 (solving inequalities (linear)), and Question 4 (complex numbers).

Table 3. Percentage frequency distribution of the attempts for each question based on the topics

Question	Topic	No. of Students Attempted (n=32)	Percentage of Attempt (%)
1	Solving inequalities: Quadratic	32	100
2	Solving inequalities: Linear	32	100
3	Solving inequalities: Absolute Value	30	93.75
4	Complex Number	32	100
5	Plane Analytic Geometry: Lines	30	93.75
6	Plane Analytic Geometry: Parabola	26	81.25
7	Plane Analytic Geometry: Circle	29	90.63
8	Domain and Range of Function	24	75
9	Inverse Function	19	59.38
10	Composite Function	18	56.25
11	Long Division	26	81.25
12	Solving Exponential Equation	16	50
13	Transformation of Graph	17	53.13
14	System of Linear Equations	32	100
15	System of Nonlinear Equations	28	87.5
16	Solving Systems of Inequalities by Graphing Techniques	25	78.13
17	Solution of Trigonometric Equation	10	31.25
18	Circular Measure: Angle	27	84.38
19	Circular Measure: Arc Length	27	84.38
20	Circular Measure: Sector Area	24	75
21	Graph of Trigonometric Function	25	78.13
22	Six trigonometric ratios and trigonometric identities: Sum of two angles	23	71.88
23	Six trigonometric ratios and trigonometric identities: Pythagorean identity	16	50
24	Solution of Triangle: Heron's Formula	22	68.75
25	Solution of Triangle: Area	20	62.5

In contrast, other questions received a high number of attempts, reaching 90% of students. Only Question 6 had the lowest attempt percentage (81.25%), but it still registered an acceptable rate. Overall, all students try to answer every question in Chapter 1. Similar results can be seen for questions drawn from Chapter 3, with all students attempting to answer Question 14, which is related to a system of linear equations. For Question 15 (a system of nonlinear equations) and Question 16 (solving systems of inequalities by graphing techniques), the percentage of students trying to answer these questions is considered quite high, with 87.5% and 78.13% respectively. Thus, it is fair to state that the majority of students attempt to answer all questions related to Chapter 1 and Chapter 3.

On the other hand, for Chapter 2, which pertains to functions, the number of students who attempted to answer the questions was relatively less compared to Chapter 1 and Chapter 3, except for Question 8 (domain and range function) and Question 11 (long division). Both questions show relatively high responses among students, with percentages of 75% and 81.25% respectively. Meanwhile, out of nine questions drawn from Chapter 4, only three have a considerable number of students attempting to answer them: Questions 18, 19, and 21, with percentages of responses exceeding 75%. Nevertheless, there are no questions which all students do not attempt to answer.

The analysis of the most and the least attempted questions, along with the full marks and average and median marks scored by students, is displayed in Tables 4 and 5.

Table 4. The Average and Median Marks for the Top Five Most Attempted Questions

Question No.	Topic	No. of Students Attempted (n=32)	Full mark	Average mark	Median Mark
1	Solving inequalities: Quadratic	32	5	3.38	4
2	Solving inequalities: Linear	32	4	2.5	3
3	Solving inequalities: Absolute Value	30	4	2.13	2
4	Complex Number	32	5	3.66	4
5	Plane Analytic Geometry: Lines	30	5	2.93	4

Based on Table 4, Questions 1 to 5 are listed as the most attempted questions. The highest mark was recorded for Question 4 (Complex Number), with an average mark of 3.66 out of 5. The median mark is 4, which suggests that many students have a good understanding of the topic. Results were similar to Question 1 (Solving Inequalities: Quadratic), where the students scored on average 3.38 out of 5 and a median of 4. Most students could apply principles in quadratic and complex number problems successfully.

However, the performance is poor for Question 2 (Solving Inequalities: Linear), where students only achieved an average of 2.5 with a median of 3, indicating moderate understanding. The lowest result is in Question 3 (Solving Inequalities: Absolute Value), where the average was 2.13 with a median of 2, indicating significant difficulty with absolute value concepts. For Question 5 (Plane Analytic Geometry: Parabola). The median score of 4 implies many students performed well; however, the mean of 2.93 suggests some students scored very low, which lowers the mean, indicating a wide variation in performance on this topic.

Moving on to the least attempted questions in Table 5, five questions are listed, with three questions from Chapter 2 (Questions 10, 12, and 13) and the rest from Chapter 4. The average score for all questions ranges from 0.5 to 1.22, indicating weak performance, lack of confidence and understanding of these topics. The same result can be observed by analysing the median value for four of the five questions, which was zero, suggesting that half of the students received no marks for these topics. All questions had 23 or fewer attempts, except for

Question 17, which received only 10 attempts and yielded a mean and median of 0.6 and 0.0, respectively. It is fair to conclude that most students refuse to answer Question 17 related to the solution of trigonometric equations. Students struggle with solving equations due to the need to identify identity and quadrants and solve equations in quadratic form.

Table 5. The Average and Median Marks for the Top Five Least Attempted Questions

Question No.	Topic	No. of Students Attempted (n=32)	Full mark	Average mark	Median Mark
10	Composite Function	18	4	1.22	0
12	Solving Exponential Equation	16	6	0.63	0
13	Transformation of Graph	17	5	1.12	1
17	Solution of Trigonometric Equation	10	5	0.6	0
23	Six Trigonometric Ratios and Trigonometric Identities	23	3	0.5	0

Consistent with the findings reported by Rohimah and Prabawanto (2020), this study reveals that students faced difficulties in solving trigonometric identity problems, including general formulas, comparison relationships, and algebraic calculations. According to Mukuka and Taura (2025), the issues encountered included algebraic manipulation, reference angles, angle relations between quadrants, and degree-radian conversion. Another study conducted by Usman and Hussaini (2017) also revealed that students often find trigonometry more difficult and complex than other areas in mathematics.

Overall, the results show students' performance patterns across different mathematics topics, indicating a learning challenge. The students showed satisfactory algebra and number manipulation mastery in topics; the same students avoided questions on transcendental equations and functions. These findings may be linked to poor basic mathematics at primary and secondary school levels, mathematics anxiety, lack of motivation and self-efficacy among students. This study purposely focused on the summative assessment as a stepping stone, since the data gives a baseline performance of mathematics knowledge before proceeding to other indicators. The findings are valuable to guide future work in designing practical formative assessment and teaching strategies to increase students' motivation in learning mathematics. Longitudinal tracking can give valuable trends of how the students' performance in Pre-Calculus can affect their learning process in other mathematics courses like Calculus, Discrete Mathematics and Linear Algebra. Ultimately, these insights aim to support efforts in improving mathematics curriculum and teaching methods to strengthen the STEM-related fields.

CONCLUSION

This study analysed the performance of repeat students in a Pre-Calculus summative assessment, showing that questions on inequalities, complex numbers, and plane analytic geometry were most frequently attempted, while trigonometric concepts, exponential equations, and composite functions were least attempted. These results highlight challenges in specific mathematical areas and focus on the need for assessment refinement and instructional emphasis on the least attempted questions. Though the assessment only includes summative assessment in terms of the written test, the findings contribute possibilities for enhancing both curriculum and assessment design. Future research should use longitudinal studies to investigate how students' achievement in the Pre-Calculus course affects their performance in subsequent courses. In addition, studies with different teaching methods and larger and more diverse groups of students, including first-time students, are necessary to confirm these findings and support improvements in STEM achievement.

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