

The Effectiveness of eCalculator in Enhancing Students' Comprehension in Calculus

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Abstract

Integrating technology into education can improve learning outcomes and teaching quality. For instance, the use of a scientific calculator, a type of educational technology, has been explored for its potential to enhance the teaching and learning of calculus. Since calculus is fundamental to fields such as science and engineering, possessing a strong mathematical and calculus foundation becomes essential for students enrolled in Science, Technology, Engineering, and Mathematics (STEM) study programs. To empower students in understanding calculus and solving problems related to differentiation and integration, an innovative tool, namely the eCALculator, has been developed. The eCALculator provides a comprehensive and accessible solution, guiding students in using a scientific calculator to learn calculus, especially in determining a function's derivatives and integrals. This innovative tool has been presented in the form of a step-by-step e-manual, which is accessible via a flipbook and includes instructional videos on using a scientific calculator, along with exercises. The tool has been tested with 40 students enrolled in calculus courses at UiTM Cawangan Pulau Pinang. Results indicate that the use of the eCALculator manual has helped students improve their comprehension of fundamental calculus concepts and enhance their accuracy in solving calculus problems. This tool, particularly beneficial for students with lower achievements in mathematics, has the potential to boost motivation and interest in learning calculus.

Keywords: Calculus, Differentiation, Integration, Scientific Calculator, STEM.

Introduction

Integrating technology into education can improve learning outcomes and teaching quality. The incorporation of hand-held technology into mathematics education is recognized as a promising approach to strengthen and broaden mathematical reasoning and comprehension. This integration not only provides access to mathematical content and problem-solving scenarios but also improves computational proficiency (Parrot & Leong, 2018). Educational technology, such as scientific calculators has been explored for their potential to extend beyond basic arithmetic operations.

Past research has demonstrated that students at various educational levels, from secondary school to university, have benefited from the incorporation of calculators in solving mathematics and calculus problems (Dagan et al., 2020; Radzuan et al., 2021; Abdul Rahman et al., 2022). Satianov (2015), who utilized an advanced scientific calculator in calculus education, affirmed its effectiveness for quick computations and as a valuable tool to enhance students' understanding of fundamental calculus concepts. Similarly, a study by Ochanda and Indoshi (2011) endorsed the benefits that students can derive from incorporating a scientific calculator in mathematics education. This integration allows students to gain a better understanding of mathematical concepts, improve their computational skills and efficiency, feel more confident in solving mathematical problems, and become more encouraged to explore further in the course.

Providing comprehensive guidance on the proper use of technological tools implemented in a course is crucial to facilitate students' learning through the technologies (Zhu et al., 2021). A specific instruction manual or module is required to guide students on how to fully utilize scientific calculators for solving mathematical and calculus problems. According to Nardo (2017), modules can promote self-directed learning by guiding students to practice and review information on their own. With minimal guidance from the teacher, they may advance independently. Once students become proficient in using a scientific calculator, they can save time when applying mathematical concepts (Darling-Hammond et al., 2020).

Recognizing the potential of scientific calculators as educational tools, the eCALculator has been created as a user-friendly e-manual designed to help students learn calculus using scientific calculators, especially in determining derivatives or integrals of functions. This innovative tool takes the form of an interactive flipbook, which includes manuals, exercises, and instructional videos to accommodate students with diverse learning preferences. In this paper, we aim to assess the effectiveness of the eCALculator manual in helping students enhance their comprehension of fundamental calculus concepts and improve their accuracy in solving calculus problems.

Methodology

The effectiveness of the eCALculator manual (Figure 1) in enhancing students' comprehension of calculus and improving their accuracy in solving calculus problems was assessed through a structured questionnaire distributed among engineering students at Universiti Teknologi MARA, Cawangan Pulau Pinang. For this study, a random sample of 40 students currently enrolled in calculus courses was selected. The questionnaire includes demographic information and queries about the eCALculator manual's effectiveness in assisting students with calculus problems, particularly in determining the differentiation and integration of functions. The specific questions from the questionnaire are outlined in Table 1.



Figure 1. The interactive flipbook of the eCALculator manual

Table 1
The Evaluation of The Effectiveness of Using eCALculator Manual

No	Questions
1	Previously I knew how to solve differentiation and integration using a scientific calculator.
2	This e-manual helps me in learning Calculus.
3	I was able to complete differentiation and integration much faster after using this manual.

Results and Discussion

Table 2 presents the demographics of 40 students participating in the study, categorized by gender and their engineering study programs. The participants comprised 62.5% female and 37.5% male. Fifty percent of the participants were students from the Civil Engineering study program, while the rest were from Mechanical Engineering (12.5%), Electrical Engineering (12.5%) and Chemical Engineering (25%).

Table 2
Summary of Students' According to Engineering Study

	Mechanical	Civil	Electric	Chemical	Total
Male	2	9	2	2	15
Female	3	11	3	8	25
Total	5	20	5	10	40

Figure 2 illustrates the findings regarding students' experiences in using scientific calculators to solve calculus problems. While the majority of students demonstrated proficiency in finding derivatives or integrals of functions using calculators, a notable percentage faced challenges. Among female students, 30.8% admitted to never acquiring the skills needed to use a scientific calculator for solving calculus problems related to derivatives and integrals, while among male students, this figure was 28.6%. Although slight differences were observed, possibly due to the small sample size, previous studies have indicated that male students tend to exhibit higher confidence in using technology, such as scientific calculators, for learning mathematics than females (Abedalaziz, 2011; Tan, 2015).

The lack of knowledge in applying calculators to solve calculus problems indicates the limited exposure of students to the applications of scientific calculators for learning calculus. For students lacking proficiency in using the scientific calculator, this signifies a missed opportunity to fully capitalize on its benefits. Polly (2008); Radzuan et al (2021) observed that students can enhance their conceptual understanding by quickly solving problems with the calculator, granting them more time to deepen their knowledge. A solid grasp of fundamental calculus concepts equips them to face challenges in solving advanced calculus problems involving derivatives and integrals.

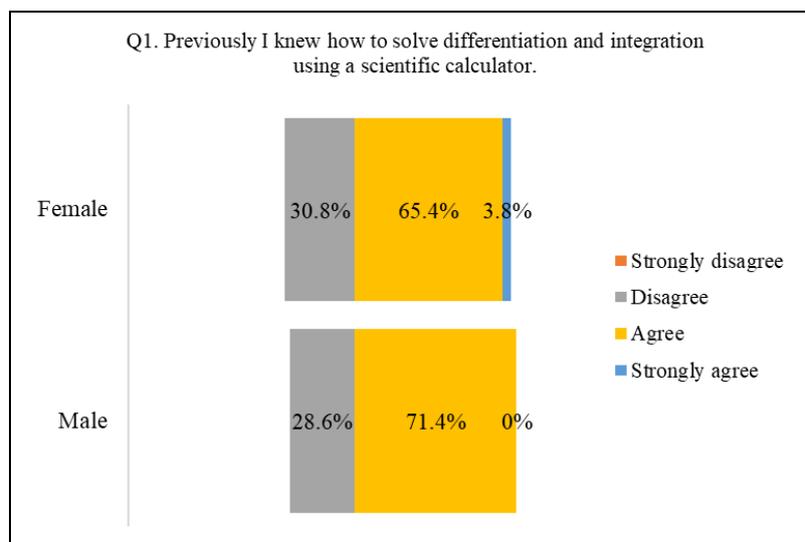


Figure 2. The usage of scientific calculator

Following the introduction of the eCALculator manual to the students, unanimous agreement arose among all students, acknowledging its positive impact on learning calculus. Specifically, 64.3% of male students and 46.2% of female students strongly endorsed the benefits of the e-manual, as demonstrated in Figure 3. Among female students, 61.5% strongly asserted their increased efficiency in solving differentiation and integration of functions after using the e-manual, while for male students, the corresponding percentage was 50%. These findings affirm that the eCALculator manual helps in guiding students on the effective use of calculators in learning calculus. They align with the conclusions of Dagan et al (2020), which emphasize that students explore numerous possibilities for mathematical thinking when provided guidance in the use of scientific calculators. Additionally, Ellington (2003) observed in her meta-analysis study the positive effects on students' performance when calculators were integrated into learning processes. The findings highlight the

importance of developing learning materials that integrate the use of calculators, as such materials are still limited (Wijaya et al., 2019).

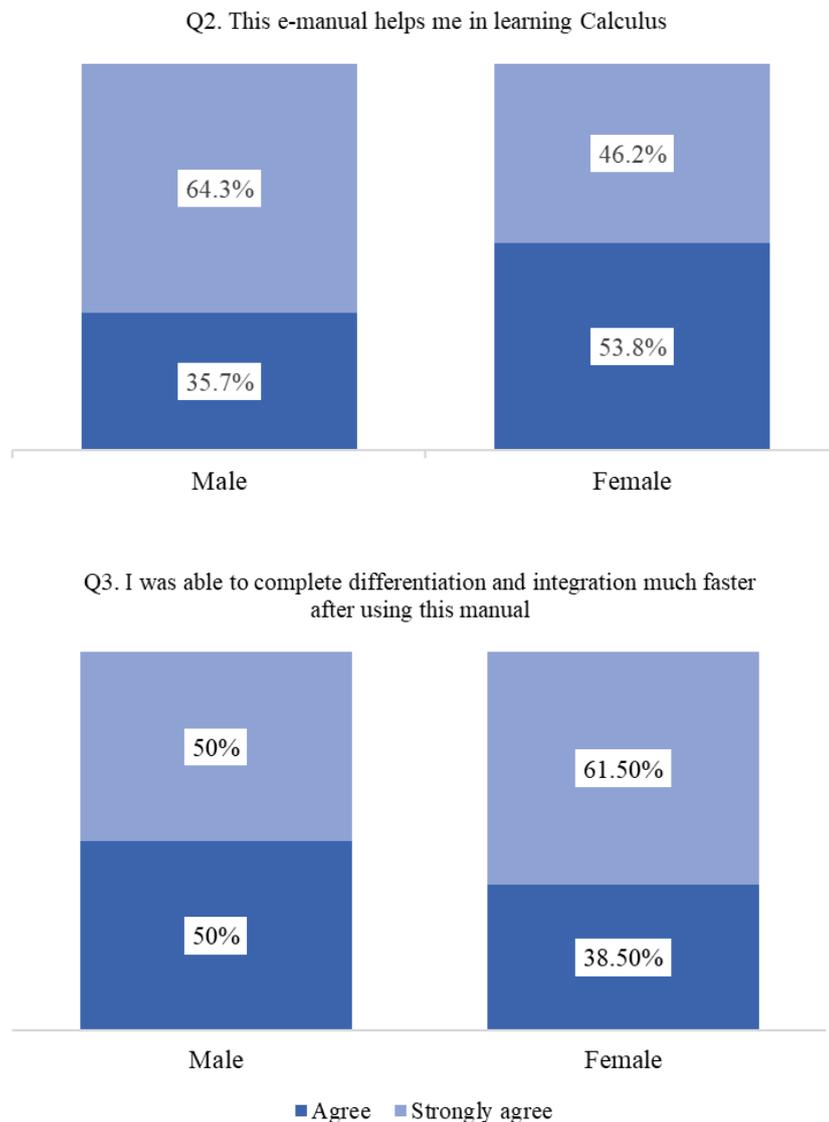


Figure 3. eCALculator manual helps students in learning calculus

Conclusion

Scientific calculators have demonstrated their important role in mathematics education, functioning not only as computational tools for students but also as aids in exploring and understanding mathematical concepts (Kissane & Kemp, 2012). This exploration of mathematical concepts holds the potential to cultivate critical thinking (Amanti et al., 2023). In this context, educators are encouraged to fully utilize the advanced functions and features of calculators in their teaching methods, making lessons more engaging, interactive, and dynamic. The findings from this study highlight that the introduction of the eCALculator manual significantly supported students in learning and solving calculus problems, especially in determining derivatives and integrals of functions. It is anticipated that the e-manual will help students enhance their comprehension and improve their problem-solving skills in calculus.

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