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Development and Evaluation of I-Promaths Module in Calculus Among Matriculation Students

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Abstract

The development of teaching aids in mathematics is crucial as a primary reference for students and lecturers. However, there is a notable issue where no specific mathematics modules or textbooks are provided by the Ministry of Education for matriculation students. Furthermore, previous studies have shown that students in higher education institutions, including those in matriculation, struggle with understanding calculus. Needs analysis also indicates that matriculation students face difficulties in calculus. Consequently, a study was conducted to develop a calculus module for the matriculation level. This module, named the i-ProMaths module, was developed using the ADDIE model, encompassing five main phases: analysis, design, development, implementation, and evaluation. During the evaluation phase, the i-ProMaths module was assessed by seven experts, including two Subject Matter Experts, two senior lecturers, a head of the mathematics unit, an excellent lecturer, and a curriculum officer. The module received a validity score of 0.95, which is very high. Additionally, the i-ProMaths module underwent a pilot study with 28 matriculation students. Reliability testing showed Cronbach's alpha value of 0.93, indicating high reliability. Hence, the i-ProMaths module can be considered to have high validity and reliability, making it suitable for use by matriculation students.

Keywords: Module, calculus, matriculation, ADDIE.

Introduction

Matriculation colleges are institutions that offer pre-university programs to secondary school graduates in Malaysia and are managed by the Matriculation Division, Ministry of Education Malaysia. Various fields of study are offered to serve as feeders to public universities in Malaysia for bachelor's degree studies. One of the important elective subjects for all the offered fields is mathematics. Calculus in mathematics is often seen as a difficult area for students to understand and needs attention (Carnell et al., 2018; Çekmez, 2020). Educators in matriculation colleges have also been striving to implement various strategies in the teaching and learning of calculus to ensure that students can master calculus well. One of the recent

studies in the field of calculus is the research conducted by Ramli et al (2024), which demonstrates that the implementation of a flipped classroom has a positive impact on calculus achievement among students in higher education institutions in Malaysia.

One of the strategies used in teaching is the use of modules to improve students' understanding of a certain topic. A module is defined as a unit composed of a series of independent learning activities aimed at helping students achieve a specific objective (Guido, 2014). Based on Zainudin (2017), he describes a learning module as encompassing various beneficial and flexible learning programs, which can be utilized both individually and in groups, with the aid of instructional intermediaries. Meyer (1998), notes that modules go beyond merely providing worksheets or textbook chapters with practice questions; when designed with clear features, they can significantly enhance learning. Several studies have highlighted the positive impact of using modules in mathematics. Yuntawati and Aziz (2018), observed a marked improvement in mathematics achievement among students who used an inquiry-based calculus module, demonstrating the effectiveness of this approach in teaching and learning calculus. Furthermore, Siregar et al (2022), emphasized the need for module development at Riau University to enhance students' creative thinking skills in calculus. Clearly, developing learning modules proves to be advantageous for both educators and learners.

At the matriculation level, the Ministry of Education does not provide textbooks or modules. Consequently, lecturers have created their own modules and notes based on the curriculum guidelines provided by the Ministry. The primary aim is to ensure lecturers comprehend the requirements and expectations outlined in the mathematics curriculum specifications, using them as a teaching guide. However, there is no standardized mathematics module for classroom delivery, and its effectiveness is assessed through experimental studies at the matriculation level. Thus, there is a need for module development to aid educators in teaching calculus to matriculation students.

A needs analysis at the matriculation level revealed that students often struggle with mathematics, particularly with the calculus topic of integration (Husain, 2021). Meanwhile, Hoban (2019), also confirmed that many pre-university students lack a solid grasp of basic calculus concepts. Various studies indicate that calculus is a challenging subject for students (Carnell et al., 2018; Çekmez, 2020), with derivatives and integration being particularly difficult (Tatar & Zengin, 2016). Hoban (2019), emphasized the widespread lack of understanding of basic calculus concepts among matriculation students, while Carnell et al (2018), pointed to poor prior knowledge as a contributing factor to the perceived complexity of calculus. During the transitional matriculation stage, lecturers play a crucial role in highlighting and teaching the fundamental concepts of mathematics, especially calculus, as these are essential for students to advance in their studies (Kouvela et al., 2018). Previous needs analyses also show that matriculation students face significant difficulties with calculus (Husain et al., 2021).

Recent research indicates that modular-based learning can enhance students' higher-order thinking skills (HOTS), including critical and creative thinking in mathematics (Feriyanto & Putri, 2020; Ibrahim et al., 2020; Maskur et al., 2020). However, most studies involving matriculation students focus on correlational (Bakar et al., 2021; Husain, 2020; Sabarudin et

al., 2019) as well as survey studies (Abd Manaf, 2021; Daud et al., 2021; Isaac & Bakri, 2021; Shaari, 2021). These studies highlight a lack of module development for pre-university students, including those in matriculation (Lim, 2016; Silk et al., 2017). Furthermore, most existing module development efforts are directed at school students. Therefore, researchers believe it is crucial to conduct a study on module development at the pre-university level, especially in matriculation.

One factor that impacts the effectiveness of teaching and learning is the use of teaching aids. Alshatri et al (2019), explained that teaching aids can assist teachers in teaching mathematics. While textbooks and reference books are still commonly used, other teaching aids like teaching modules, self-learning modules, or training modules are alternative options for teachers or lecturers. Consequently, many course books now have a modular structure instead of a unit structure (Sadiq & Zamir, 2014). Murray (1985), describes a module as a complete, independent teaching unit focusing on achieving specific objectives. Russell (1974), defines a module as a comprehensive teaching unit aimed at achieving a stated learning outcome, ensuring students master one lesson unit before moving to the next. Nardo (2017) further explains that a module is a well-structured learning framework for a specific topic, including learning instructions, specific objectives, teaching and learning activities, and assessments. Finally, Mohd and Ahmad (2005), describe a module as a systematic and orderly teaching and learning unit on specific themes, empowering students to learn independently and complete a learning unit.

The use of modules as a teaching-learning approach is gaining popularity. Instead of using a textbook, teachers employ modular-based learning for specific objectives (Malik, 2013). Studies suggest that using modules can enhance student mastery (Kamil & Yusoff, 2022), serve as an effective teaching approach (Ambayon & Millenes, 2020), improve student-centered learning (Larawan, 2013), and encourage active thinking (Setiyadi, 2017). Various studies have examined the use of modules in teaching and learning. Khalil and Yousuf (2021) did an experiment with 30 secondary students in Statistics, dividing them into control and treatment groups. The control group used traditional techniques, and the treatment group used a modular approach. The findings showed the treatment group performed better in mathematics achievement than those in the control group.

The Fun Learning Enrichment Program (FLEP) module, developed by Bakar et al. (2018), aims to boost motivation among underachieving students. Six rural primary schools were divided into control and treatment groups. Students in the control group followed the standard program, while those in the treatment group used the FLEP module. After the experiment, a questionnaire on motivation revealed that treatment group students were more motivated than control group students. Budi and Sunarno (2018), studied the effect of modular-based learning on critical thinking in science, involving 64 students in a true experiment. The post-test results showed that students in the treatment group performed significantly better in critical thinking skills than those in the control group.

At the matriculation level, Husain et al (2021), developed a calculus module using the Sidek model. This module has high validity and reliability but has not been tested for effectiveness through experiments. There is a need for a calculus module tested for effectiveness at the matriculation level. Gonzales (2015), also developed an online-modular calculus module

tested with a quasi-experiment on undergraduate students. The study showed that the treatment group performed better than the control group. Fadzil and Mahmud (2020) developed a biology module on cellular respiration using project-based learning for matriculation students. In a quasi-experimental study with 38 students in the treatment group and 35 in the control group, the findings revealed that the treatment group performed better in biology. However, project-based learning requires more time, which is challenging given the dense syllabus at the matriculation level. In conclusion, using module-based learning is an effective alternative for helping lecturers to manage teaching and learning. Modules encompass specific learning goals tailored to student needs.

The Study

This study focuses on the development and evaluation of calculus module developed at the matriculation level. Therefore, there are two main objectives in this study:

1. To determine the validity of the i-ProMaths module through expert opinion.
2. To determine the reliability of the i-ProMaths module.

Methodology (Design and Development of i-ProMaths Module)

The process in this study involves the development and evaluation of a calculus module at the matriculation level which is named the i-ProMaths module. This module was developed using the flipped classroom approach and problem-based learning based on the findings of the needs analysis. The research conducted is in the form of a quantitative survey method using a validation instrument through a questionnaire. The sampling used in this study is purposive random sampling. This study was conducted on seven experts in order to get feedback on the suitability, advantages and disadvantages of the developed module.

This process only involves content experts. The development and evaluation process of this i-ProMaths module has been implemented by involving seven content experts, namely two Subject Matter Experts (SME), two senior lecturers, one excellent lecturer, one head of the mathematics Unit and one curriculum officer with experience in the subject of mathematics at the matriculation level. Expert assessment involves assessment of the content, delivery and assessment of the module. The determination of the appropriateness level refers to the acceptance level table that has been built by Kenayathulla and Jupri (2017). This table serves as a guide in determining the level of suitability based on the mean score value to interpret the data obtained.

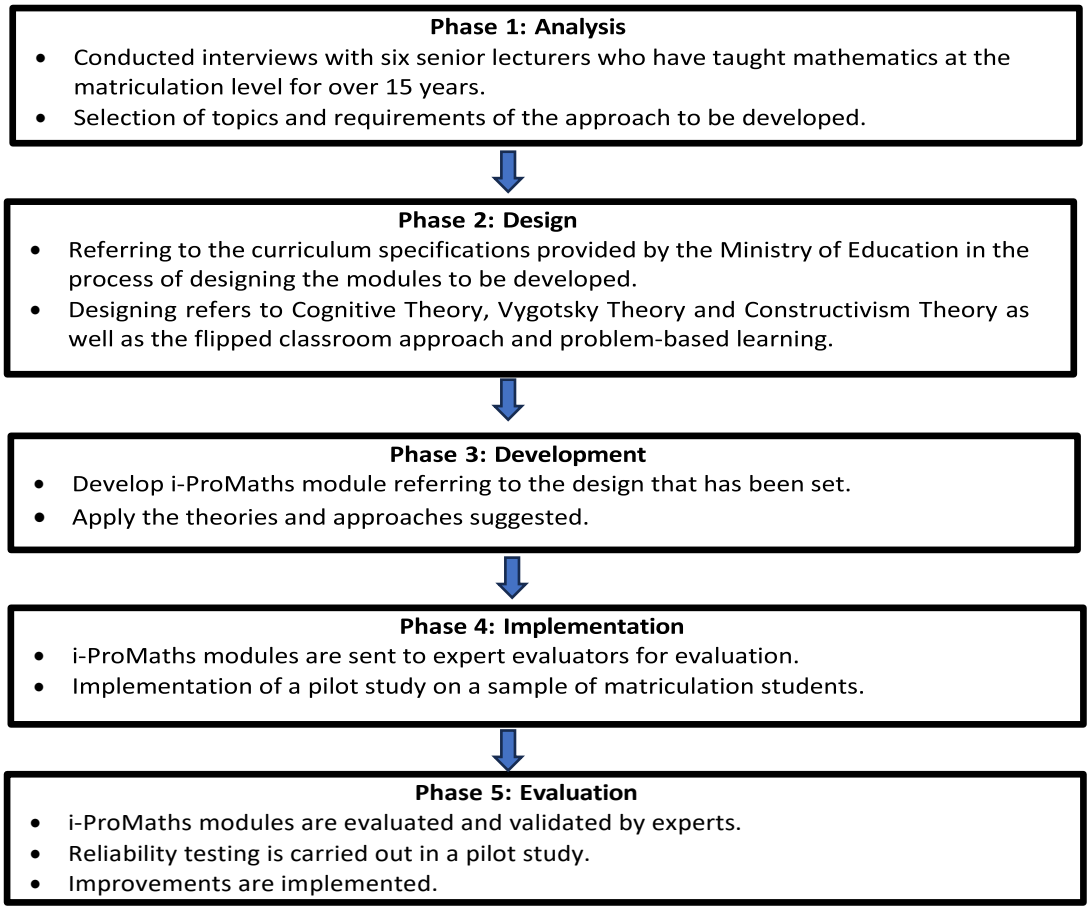

Figure 1. Summary of i-ProMaths Module Development

The development and evaluation process of the i-ProMaths module follows the ADDIE model, which comprises five phases: analysis, design, development, implementation, and evaluation. Mohan et al (2008), highlight the ADDIE model as a prominent systematic process for instructional design, recognized for its effectiveness. Sari (2016), details that the ADDIE model encompasses five systematic phases that designers must adhere to. These phases are widely adopted as fundamental steps in instructional design models (Richey & Klein, 2014). This study presents the i-ProMaths module, developed using the ADDIE model, which includes five phases: analysis, design, development, implementation, and evaluation. The ADDIE framework was utilized to create and develop this module, ensuring it aligns with the students' learning goals and requirements. Additionally, Figure 1 provides an overview of the development and evaluation process of the i-ProMaths module.

According to the needs analysis, the i-ProMaths module should incorporate two learning approaches (flipped classroom and problem-based learning) and involves three phases: pre-class, in-class, and post-class. Figure 2 illustrates an overview of the strategies utilized in the i-ProMaths module. During the pre-class phase, students access short notes, solution videos, teaching videos, and quizzes via a QR code. The in-class phase focuses on active student participation through group discussions.

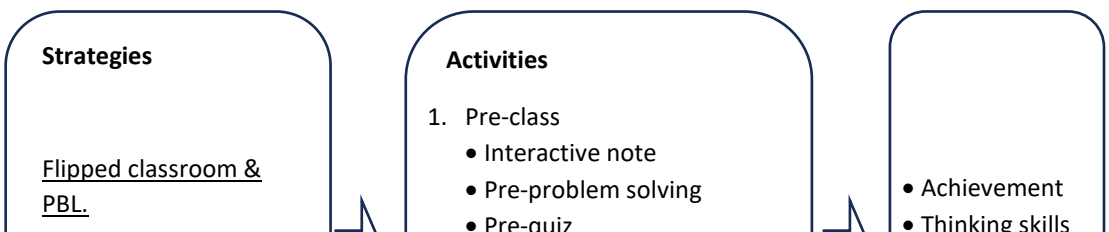

Figure 2. Strategies in i-ProMaths Module

The modular approach has been utilized in educational software to enhance teachers' pedagogical skills for teaching mathematics (Bahagian Pembangunan Kurikulum, 2018). With the advent of the internet, smartphones, and various applications, traditional teaching methods have shifted towards mobile learning using wireless technology (Gnanasagaran & Amat, 2019). This module facilitates learning without boundaries, allowing students to study at their convenience. Arif et al (2021), describe modules as learning materials designed for self-directed learning, which is suitable for mature matriculation students who can plan their own learning paths. Moreover, using modules helps users not only understand the lesson content but also master the topics covered (Cruz & Rivera, 2022). The i-ProMaths module aims to enhance students' comprehension of integration, a topic identified as challenging in previous sessions through needs analysis. Since matriculation colleges do not provide textbooks, modules, or reference books from the Ministry of Education, this module aids lecturers in delivering focused teaching and learning on the selected topic. Additionally, the module is user-friendly and helps develop students' thinking skills. Matriculation students practice foundational knowledge and skills with lower-level questions during pre-class, progressing to higher-level questions in in-class sessions. Student presentations and discussions during tutorials further enhance critical and creative thinking skills, encouraging them to present and critique solutions. This module also helps lecturers complete the syllabus efficiently and prepares students for learning sessions.

Results

Evaluation of Module

The evaluation of the module in this study incorporates expert validity and reliability through a pilot study. The validity of a module reflects how well it achieves its intended outcomes. High validity means the module effectively meets its objectives. As per Noah and Ahmad (2005), validity measures the content's adequacy. The researchers enlisted seven experts and determined validity scores based on their evaluations. Noah and Ahmad (2005), and Tuckman and Waheed (1981) suggest that a content validity level above 70 percent is acceptable. According to the percentage calculation, the content validity of the i-ProMaths module has exceeded 70 percent, specifically reaching 95.31%, with a validity coefficient of 0.95 (see Table 1). Thus, the i-ProMaths module has attained a high level of content validity.

Table 1
Measurement of content validity

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	
1. The module's content is suitable for matriculation students.	10	10	10	10	9	9	9	
2. The module's content is in line with the matriculation syllabus.	10	10	10	10	10	9	9	
3. The module's content meets the concept of thinking skills.	10	10	9	9	10	10	8	
4. The module's content is able to effectively improve the students' level of mastery in calculus.	10	10	10	9	9	10	9	
5. The module's content according to the curriculum specifications that have been set by Ministry of Education.	8	9	10	9	10	10	8	
6. The module's content uses the correct terminology of Mathematical language.	10	10	10	10	9	10	9	
7. The module's content uses the correct structure of Mathematical language.	10	10	10	9	9	10	9	
Total	68	69	69	66	66	68	61	
			Content Validity Percentage (100%)					95.31
			Content Validity Coefficient (1.00)					0.95

The majority of the feedback from experts was positive. They noted that the module aligns with the latest curriculum specifications and uses clear, simple language. The inclusion of brief notes and QR-code-linked explanatory videos was found to be helpful for students. The questions in the module were also deemed appropriate. However, experts suggested some improvements, such as enhancing certain questions, adding more diverse question types,

reducing the number of pre-class questions, and providing hints for reinforcement questions in post-class activities. The researcher has taken all suggestions into account, discussed them with the experts, and decided to implement the recommended changes. Table 2 provides a summary of the comments, suggestions, and improvements made to the i-ProMaths module. In conclusion, the developed module is valid and of high quality, with suggested improvements implemented.

Table 2
Validation expert feedback and improvements

No	Expert	Comments and Suggestions	Corrections
1	Expert 1 (Head of mathematics Unit)	The materials in this module align with the latest curriculum guidelines and use clear, easy-to-understand mathematical language. They should be regularly updated to match curriculum changes.	Updated to reflect the latest curriculum specifications.
2	Expert 2 (SME)	The module adheres to the SM025 mathematics curriculum and covers all relevant subtopics. It is suitable for teaching, learning sessions, and student exercises, emphasizing pre-class, in-class, and post-class learning.	-
3	Expert 3 (Senior lecturer)	The limited number of questions ensures students grasp each step, with enough time allocated for understanding. Pre-class questions should be limited to 2-3.	Pre-class questions have been reduced to 1-2.
4	Expert 4 (SME)	The module is designed for matriculation students, with content organized around learning objectives and the latest curriculum specifications. Explanatory videos and brief notes for each subtopic enhance student understanding and ease of access. Adding links to reference materials or relevant YouTube videos is recommended to help students navigate different sources.	Several lecture videos are accessible via the mylinkla application using QR codes on the module's front page.
5	Expert 5 (Excellent teacher)	The materials are appropriate for the learning level and cover all subtopics, using language and structure consistent with exam questions.	-
6	Expert 6 (Senior lecturer)	Most materials meet learning objectives, a few questions require improvement, and hints should be provided for reinforcement questions.	The researcher has collaborated with experts to revise and enhance the questions.
7	Expert 7 (Curriculum officer)	The materials are appropriate for the students' level and match the latest curriculum learning objectives. They use clear language and include supporting materials accessible via QR codes. The questions align with the learning unit and come in varied forms.	Based on discussion with expert, the researcher added questions, particularly on area and volume subtopics, as recommended.

Discussion, Conclusions and Recommendations

The i-ProMaths development and evaluation process is based on Constructivism Theory, Cognitive Theory and Vygotsky Theory and uses the flipped classroom approach and problem-based learning with the five phases of the ADDIE model. Each development process involves evaluation from experts who have been selected to ensure the functionality of the i-ProMaths module meets the need analysis (Ibrahim et al., 2018). The results found that all experts agreed at a high level that the i-ProMaths module developed met the required criteria. Evaluation of the content of the module, interface design and technical use of the i-ProMaths module has been evaluated and the validity of the content has been determined. Therefore, in line with finding of Husain et al (2021), who found that the delivery of teaching and learning through module can improve the understanding of matriculation students in calculus. Based on the findings at five phase of ADDIE model, it is clear that the module development process had gone through several rigorous processes before testing its effectiveness. The implementation phase of the i-ProMaths module was carried out on a pilot study at one matriculation college with certain criteria set in this study. Finally, an i-ProMaths module validity and reliability evaluation was conducted to assess the extent to which i-ProMaths module achieved the intended module objectives.

The development of modules in calculus at the matriculation level has become a reference source for students and teaching aids for lecturers in addition to creating more interactive and dynamic learning (Burhan et al., 2017). However, there is still room to improve this study. Some follow-up studies can be done on this study to further strengthen the study results obtained, one of which is to expand the scope of the study to the areas of Algebra and Statistics towards matriculation students.

The results of the analysis that has been carried out show that the feedback from experts is positive and the analysis results show that the i-ProMaths module that has been developed meets the criteria and needs of users. It is hoped that through the development of i-ProMaths this module can help matriculation students to better understand topics related to calculus in addition to enhance their mathematics achievement scores at the matriculation level.

Understanding and mastering calculus is crucial for pre-university and matriculation students, as it forms the foundation for advanced studies in certain courses in university. Despite its importance, many students in these programs struggle with calculus concepts, leading to a need for effective teaching resources. This study aims to address this gap by developing a comprehensive calculus module tailored specifically for pre-university and matriculation students, enhancing their understanding and critical thinking skills. By rigorously evaluating the module's validity and reliability, this research contributes to the field of mathematics education, providing educators with a proven tool to boost student performance. The findings from this study have the potential to significantly impact the way calculus is taught at the pre-university level, making it more accessible and engaging for learners.

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