

Computational Thinking-Based Calculus E-Module to Improve Students' Mathematical Literacy Skills

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Abstract

This research and development are based on the need for teaching materials that are in accordance with the current situation and conditions in the digital era. The purpose of this research is to Develop Computational Thinking-Based Calculus E-Module to Improve Students' Mathematical Literacy Skills that are valid and practical. This type of research is research and development (R&D) through the Analyze, Design, Develop, Implementation and Evaluation stages or also known as the ADDIE model. The research instruments are in the form of e-module validation questionnaires, lecturer and student response questionnaires and student mathematical literacy skills tests. Data analysis was used to obtain results in improving students' mathematical literacy skills through a gain score test. Based on the results of data analysis, it was obtained that 1) the computational thinking-based calculus 1 e-module was declared valid with a value of 0.72 indicating a high validity category, 2) the results of the lecturer response questionnaire of 84.00% and the student response of 81.06% showed that the computational thinking-based calculus E-module was very practical to be used by students and lecturers, and 3) the computational thinking-based calculus E-module was effective in improving students' mathematical literacy skills by the results of the limited trial and the field trial with an N-gain value of 0.74 in the limited trial and 0.77 in the field trial with the high category. Thus, the computational thinking-based Calculus e-module developed is very practical and effective to be used to improve students' mathematical literacy skills.

Keywords: Calculus e-module, computational thinking, mathematical literacy, research and development.



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INTRODUCTION

The process of online teaching and learning activities is a program of the Ministry of Education and Culture (Kemendikbud). It was initiated in 2014 (Yuliana, 2020), and it was forced due to the Covid-19 tragedy (Mulyono et al., 2021). Online learning certainly requires appropriate teaching materials to support teaching and learning activities (Sirk, 2024). Calculus lecture activities, for example, require teaching materials that are adaptive and easily accessible to users through smartphones or computers such as electronic modules. Therefore, the implementation of technology products such as e-modules in lectures must be developed to have a design that suits the needs and capacities of students. Teaching materials support learning process activities (Sefina Samosir et al., 2021). The quality of e-modules can be measured based on validity, practicality, and effectiveness (Pamungkas, 2017). They should be designed so that systematically adjusting to the current curriculum will make students learn independently more efficiently and meaningfully.

Currently, most e-modules focus more on understanding the material than developing soft skills (Kurniawati & Amarlita, 2013). In the Engineering Department of the University of Muhammadiyah Banten students, some lecturers still use makeshift references without making their own teaching materials to support learning activities. Several problems are obstacles for students majoring in Engineering at the University of Muhammadiyah Banten, especially in studying the material, including (1) the material discussed in the reference book is challenging to understand because it contains complex and unfamiliar abstract concepts; (2) the availability of teaching modules is still limited; (3) Still using teaching modules that are not in accordance with the needs of students because a coordinating team of experts does not carry out the preparation of modules. These various problems can automatically affect improving students' basic mathematical skills, which are urgent in learning calculus, especially students' mathematical literacy skills.

Mathematical literacy skills are as important skills (Genlott & Grönlund, 2016), especially in the 21st century where almost every human activity requires skills in such as critical thinking, problem-solving, and data analysis (Komarudin et al., 2024). There are many skills that are important for students to have, one of which is mathematical literacy skills. Mathematical literacy involves logic and mathematical thinking patterns (Mahdiansyah & Rahmawati, 2014). In addition, another opinion states that mathematical literacy skills can make students able to relate the results of calculus learning activities with the factual context in life, and be able to better analyze the application of mathematical concepts (Manoy & Purbaningrum, 2021). A person is said to be literate or mathematically literate, meaning that a person is not limited to understanding mathematical problems but is also able to apply them in a factual context (Sulistiawati et al., 2021). Mathematical literacy plays a fundamental role for a person in making a judgment and decision and mathematically has measurable justification (OECD, 2015). In addition, mathematical literacy should be owned by everyone in the 21st century along with the development of technology (Mahiuddin et al., 2019). In line with that, Yildirim also considers mathematical literacy as a skill that is as important as technological skills (Yildirim & Sidekli, 2018). Another opinion considers that mathematical literacy skills are also considered as a skill in solving cases that emphasize factual context (Nurlaili et al., 2022). Details mathematical literacy

skills as mathematical reasoning, the application of mathematical concepts and tools in describing a (Setiawan et al., 2019). Therefore, the application of more complex mathematical literacy in calculus courses in particular includes several points or stages, namely: as a skill in (1) Interpreting/providing theoretical views in the form of appropriate theorems/formulas; (2) Representing complex cases in the form of mathematical models; (3) Designing case/problem resolution; (4) Making conclusions from the results of the case settlement; (5) Apply theorems in solving factual cases; (6) Communicating the results of the analysis of the case/problem solving.

Meanwhile, the reality that occurs in calculus learning at this time is still far from achieving success in improving students' mathematical literacy. Another opinion clarifies the problem that students' mathematical literacy skills based on gender, both male and female, are still relatively low (Mahiuddin et al., 2019). Another fact found that the problems faced by individuals with low mathematical literacy skills include difficulties in formulating, interpreting, and applying theorems (Yustitia & Juniarso, 2020). More specifically in calculus courses, the results of the study found that students were actually able to understand cases but had difficulties in transforming and coding cases (Setyawan & Astuti, 2021). Various previous studies have shown that lecturers or educators need better strategies in improving mathematical literacy skills, especially in calculus courses that are almost studied by students from various majors.

Electronic modules or e-modules are tools in presenting teaching materials that are designed in such a way to facilitate the learning process and adjust to the applicable needs and curriculum. The implementation of technology products such as e-modules in lectures must be developed to have a design that suits the needs and capacities of students. Basically, E-modules contain important substances in learning in the form of learning design, media used, clearer and concise discussion of material accompanied by case examples and designed systemically based on the expected course learning sub-outcomes. The use of technology greatly facilitates the development of student competencies (Domingo & Garganté, 2016). Therefore, the design of teaching materials in the form of E-modules has an interesting advantage when compared to ordinary modules because of their interactive shape and design (Furqan et al., 2016). E-modules should be developed to be able to accommodate abstract cases and theorems in learning (Setyawan & Astuti, 2021). Calculus e-modules that are well designed according to the needs and capacities of students in the digital era, adapt to technological sophistication and can improve students' mathematical literacy skills can be developed through various approaches. There are many approaches that can be used, but the approach that suits the current situation and conditions of calculus lectures includes Computational Thinking (CT).

E-modules should be adapted to the latest technological advances and sophistication, Computational Thinking can be aligned with reading, writing, and numeracy skills (Grover & Pea, 2013). This means that computational thinking is very appropriate to be applied in the development of calculus E-modules because it is equivalent to or has become a basic human ability in today's digital era. Interestingly, through e-modules based on Computational Thinking, students can be aimed at logical, mathematical, mechanical thinking and the whole can be combined with the latest technological knowledge (Ansori, 2020). Computational thinking can be in the form of learning activities with lecturers as facilitators that decompose abstract theorems (Jiang & Wong, 2022). Kawuri divided 5 stages in the development of computational thinking-

based calculus E-modules, namely (1) decomposition, (2) pattern recognition (3) abstraction, and (4) algorithms (Kawuri; Santeri et al., n.d.). Computational thinking is able to construct complex cases into simpler ones, apply previous problem-solving experience in solving new cases, filter out unimportant concepts, design solving strategies scientifically, and revitalize problem-solving strategies (debugging) (Jiang & Wong, 2022).

Therefore, the development of computational thinking-based E-modules can be a solution to improve students' mathematical literacy skills in today's digital era by applying decomposition, pattern recognition, abstraction, algorithms and debugging stages that are relevant to the need to improve students' skills in interpreting, representing, calculating, assuming, applying as well as analyzing and communicating the results of completion cases in calculus. The above problems are an important reason for researchers to develop Computational Thinking-based Calculus E-modules to improve Students' Mathematical Literacy Skills.

METHOD

This research is research and development (R&D) in designing new procedures or products in this case e-modules, which are then systematically tested, evaluated, and improved in order to achieve the desired effectiveness and quality (Gall and Borg, 2003; Gustiani, 2019). R&D aims to create new products that are more authentic (Sugiyono, 2014) in physical form such as tools and books, or in the form of software such as computer programs (Sukmadinata, 2019).

The computational thinking-based calculus e-module is the object of this study with students in the calculus course for the 2023/2024 academic year at the Department of Engineering, University of Muhammadiyah Banten as the subject of the research. This study aims to develop a Computational Thinking-Based Calculus E-Module to Improve Students' Mathematical Literacy Skills by using the ADDIE development model which includes the stages of Analyze, Design, Develop, Implementation, and Evaluation.

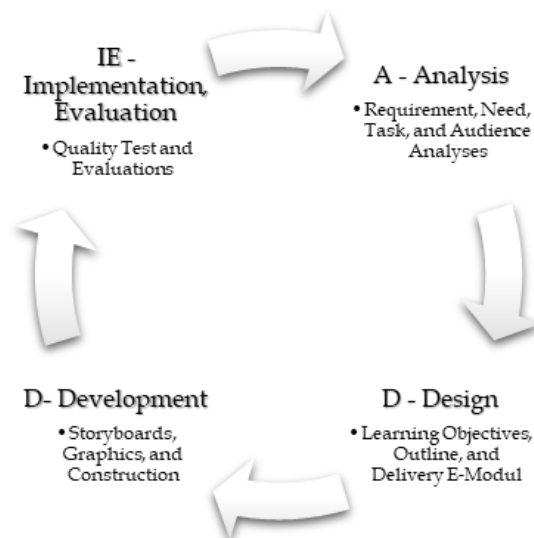


Figure 1: The ADDIE Model

Data analysis in this research was carried out to get an overview of the validity of the Computational Thinking-Based Calculus e-module, students' responses to the e-module, and the achievement of students' mathematical literacy skills. The validation sheet is used to find out the assessment of experts related to the developed Calculus e-module. The validation calculation uses the following Aiken formula:

$$V = \frac{\sum s}{n(c - 1)}$$

Information:

V = validation index

s = the difference between the set score and the lowest score

n = number of validators

c = Highest validity assessment result

Table 1. Criteria for the validity of e-modules

Percentage NA (%)	Qualification
$0,80 < V \leq 1,00$	Very high
$0,60 < V \leq 0,80$	Tall
$0,40 < V \leq 0,60$	Enough
$0,20 < V \leq 0,40$	Low
$0,00 < V \leq 0,20$	Very low

(Azwar, 2001)

The stage to determine the level of consistency of the e-module used, a reliability test is carried out. The following is a run to calculate the reliability of computational thinking-based calculus e-module assessment instruments (Santeri et al., 2024):

$$\text{percentage of agreement (R)} = 100\% \left(1 - \frac{A - B}{A + B} \right)$$

Information:

R = Instrument reliability

A = Frequency of scoring from validators who provide high scores

B = Frequency of ratings from validators with low scores

If the reliability of the instrument $\geq 75\%$, the assessment instrument can be said to be reliable (Borich, 1994; Santeri et al., n.d.).

Practicality of E-Module Based on Computational Thinking

The practicality data obtained is based on the practicality value obtained from the results of the data collection instrument in the form of a response questionnaire filled out by lecturers and students as users in the field test (Santeri et al., 2024). The score obtained from each questionnaire

is determined on average. The average score is converted into a percentage form with the formula:

$$P = \frac{\sum K}{\sum N} \times 100\%$$

Information:

P = percentage number

$\sum K$ = the number of scores from respondents

$\sum N$ = maximum number of scores for all respondents

The following measures are the basis for categorizing the practicality of computational thinking-based calculus E-modules, shown in table 2.

Table 2. Criteria for categorizing practicality

Value Interval	Category
81-100	Very practical
61-80	Practical
41-60	Less practical
21-40	Impractical
0-20	Very impractical

(Meliana M et al., 2022)

Student Mathematical Literacy Skills Test

To see the improvement of students' mathematical literacy skills in solving calculus cases which include theorems, application and analysis of their applications, tests are carried out. Mathematical literacy skills test questions that have been validated by expert lecturers can be seen in the attachment.

At the correction stage, the results of the student test were based on the high, medium, and low categories of mathematical literacy skills indicators by randomly selecting 3 students as representatives with high, medium, and low mathematical literacy skill criteria. After that, the student's answer sheet is analyzed and the student concerned is asked for the explanation needed to strengthen and clarify the assumptions given. As for the grouping of students from high, medium to low, the researcher used the (Arikunto, 2011) criteria, shown in table 3.

Tabel 3. Criteria for Students' Mathematical Literacy Skills

Value	Group
$X \geq (\bar{x} + SD)$	Hugh
$(\bar{x} - SD) < X < (\bar{x} + SD)$	Medium
$X \leq (\bar{x} - SD)$	Low

(Arikunto, 2011)

The researcher used triangulation to analyze the data, including: (1) the data reduction stage where the results of the students' mathematical literacy skills test were analyzed using indicators that had been made previously. (2) The next stage is to present the data from the analysis of the answer sheets and the results of student presentations. (3) The last stage is that the researcher concludes the results of the research that has been analyzed. The following are the indicators of mathematical literacy adapted from (Rafianti et al., 2018) in this study shown in Table 4.

Table 4. Mathematical Literacy skill indicators

Mathematical process	Mathematical Literacy Skill Indicators
1. Interpreting/providing theoretical views in the form of appropriate theorems/formulas;	1. Interpret
2. Representing complex cases in the form of mathematical models;	2. Represent
3. Designing case/problem resolution	3. Calculate
4. Make a conclusion from the results of the case settlement	4. Assume
5. Applying theorems in solving factual cases	5. Apply and analyze
6. Communicate the results of the analysis of the case/problem solving	6. Communicate

(Rafianti et al., 2018)

RESULTS AND DISCUSSION

Validation of Computational Thinking-Based Calculus E-Module to Improve Students' Mathematical Literacy Skills

The e-module was validated by 2 experts and 1 practitioner with the aim of measuring the feasibility and suitability of the e-module with mathematical literacy skills (Gronlund & Linn, 1990;Nurul Ainun Islamia, 2018). The focus of validation is on content and media validation. The results of the e-module validation are presented in table 5.

Table 5. Validator evaluation

No	Assessment Aspects	Validator								Validati on Index
		1	2	3	s1	s2	s3	$\sum s$	$n(c-1)$	
1.	Eligibility	4	4	3	3	3	2	8	9	0,89
2.	Linguistics	3	3	3	2	2	2	6	9	0,67
3.	Serving	3	4	3	2	3	2	7	9	0,78
4.	Graphics	3	3	2	2	2	1	5	9	0,56
5.	User convenience	4	3	4	3	2	3	8	9	0,89
6.	Consistency	4	3	3	3	2	2	7	9	0,78

7.	Format	3	2	3	2	1	2	5	9	0,56
8.	Design appearance	3	3	3	2	2	2	6	9	0,67
9.	Benefits	3	3	3	2	2	2	6	9	0,67
Rata-rata		0,72								

Based on Table 5, the results of the assessment by the validator as a whole are 0.72 with high validity criteria. Overall, based on Table 2, the results of the Validation of the Computational Thinking-Based Calculus E-Module by 3 validators are in the valid category. The e-module obtained a very valid category in terms of content feasibility and user convenience, showing that the feasibility of the content of the material in this calculus e-module is very considered. One of the things that must be considered is what device will be used when students use the e-module (Najuah, et al. 2020;Santeri et al., n.d.)). The aspect of user ease categorized as very valid shows that the Computational Thinking-Based Calculus E-Module makes it easier for students to access learning and makes it easier for lecturers to communicate learning with more effective time (Jafnihirda et al., 2023). This Computational Thinking-Based Calculus E-Module is adjusted to make it easier for students to access this e-module through smartphones and laptops. The e-module is designed in such a way that students are not confused when using it.

Limited Trial

In this study, a readability test was carried out first before the limited trial stage (Nindiasari, 2011) to three students majoring in Engineering at the University of Muhammadiyah Banten.

Table 6. Results of the E-Module Practicality Questionnaire at the Limited Trial Stage

No	Assessment Aspects	Average Score				Percentage
		1	2	3		
1.	Presentation of Materials	3	4,67	4	3,89	78
2.	Linguistics	3,33	3,33	4,33	3,67	73
3.	Graphics	3,5	3	4	3,5	70
4.	Benefits	4,5	5	5	4,83	97
Average		79				

Table 6 shows that the average percentage of practicality is 83% with the category "very practical". The aspect of usefulness in the practicality of the e-module in the limited trial is that it has a percentage of 96.67% with the category of very practical. This aspect has the highest percentage in limited trials. This data shows that students recognize and feel for themselves the benefits of this computational thinking-based calculus E-module which is very suitable for the needs of students in the digital era.

To determine the effectiveness of this calculus e-module, the researcher used a test instrument for students' mathematical literacy skills that had been validated through pre-test and post-test presented in table 7.

Table 7. The results of mathematical literacy skills per indicator in the limited trial stage

No.	Indicator	Pre-Test Value	Post-Test Value	N-gain <g>	Note
1.	(1) Interpreting/ providing theoretical views in the form of appropriate theorems/formulas; (2) Representing complex cases in the form of mathematical models;	1,48	3,89	0,68	Medium
2.	(3) Designing case/problem resolution; (4) Making conclusions from the results of the case settlement;	1,38	4,26	0,80	High
3.	(5) Apply theorems in solving factual cases;	1,94	3,89	0,64	Medium
4.	(6) Communicate the results of the analysis of the case/problem solving	1,67	4,51	0,85	High
Average		0,74		High	

The results of the pre-test and post-test show that the results of the mathematical literacy skills indicators at the first meeting, out of 4 indicators of mathematical literacy skills, none have been achieved, this means that in general students have not mastered mathematical literacy skills. After the learning process using computational thinking-based e-modules, it turned out that there was an increase in indicators of mathematical literacy skills. This is strengthened by the value of Ngain, a mathematical literacy skill indicator which has a value of 0.64-0.85, which means the level of improvement of each mathematical literacy skill indicator in a limited trial, some are in medium criteria and high criteria.

Field Trial

To determine the practicality and effectiveness of the e-module developed, the implementation stage was carried out through a field trial of the Computational Thinking-Based Calculus E-Module. At this stage, the learning process was carried out using the Computational Thinking-Based Calculus E-Module for 32 students majoring in Engineering, University of Muhammadiyah Banten. Before the learning process begins, students are first tested for mathematical literacy skills by conducting a pre-test.

Furthermore, the learning process was carried out 3 times. At the first meeting of the history of the development of calculus, the second meeting of the basic principles of calculus, and the third meeting of examples of calculus applications in the field of engineering. After the learning process is carried out, a post-test will be carried out to see the improvement of students' mathematical literacy skills. In addition, at this field trial stage, after the meeting of the three students, a response questionnaire was given to provide a response to the practicality of the

Computational Thinking-Based Calculus E-Module to Improve Students' Mathematical Literacy Skills which was given to 3 calculus lecturers and 32 engineering students who took part in the field trial. The results of the practicality/response questionnaire of lecturers and students are presented in table 8.

Table 8. *Practicality of CT-Based Calculus e-Module to Improve Students' Mathematical Literacy Skills*

Respondents	Number of Statements	Number of Respondents	Average Score	%	Category
Lecturer	10	3	4,20	84,00	Very Practical
Student	10	32	4,05	81,06	Very Practical

In Table 8, the results of the practicality of lecturers and students in the field trial of 3 calculus lecturers were obtained with an average percentage of scores from the 4 aspects of the statement, namely material presentation, language, graphics, and usefulness, as well as the conformity with the CT-based e-module which was 84.00% which showed that the Computational Thinking-Based Calculus E-Module was very practical to be used in Calculus learning activities at the University of Muhammadiyah Banten, majoring in engineering.

Meanwhile, for the response questionnaire given to 32 students, an average percentage of scores from the four aspects of the same statement was obtained, which was 81.06% with the category of very practical. The practicality of the e-module in the field trial, namely the usefulness aspect, has a percentage of 93.33% (lecturer response) and 87.92% (student response) with a very practical category, obtaining the highest percentage among other aspects as well as in limited trials. The results of the questionnaire responses of lecturers and students show that this computational thinking-based calculus e-module is very beneficial for both students and lecturers in providing more effective and efficient learning.

Student Mathematical Literacy Skills Test

The results of the mathematical literacy skills test for students majoring in Engineering, University of Muhammadiyah Banten, semester 2 of the 2023/2024 academic year are presented in Table 9.

Tabel 9. *Results of Mathematical Literacy Skills Test per Indicator at the Field Trial Stage*

No.	Indicator	Pre-Test Value	Post-Test Value	N-gain <g>	Note
1.	(1)Interpreting/providing theoretical views in the form of appropriate theorems/formulas; (2) Representing complex cases in the form of mathematical models;	1,90	4,33	0,78	High
2.	(3) Designing case/problem resolution; (4) Making conclusions from the results of the case settlement;	1,36	3,84	0,68	Medium

3.	(5)Apply theorems in solving factual cases;	1,08	4,47	0,87	High
4.	(6)Communicate the results of the analysis of the case/problem solving	1,07	4,06	0,76	High
Average		0,77		High	

The results of the pre-test and post-test based on the students' mathematical literacy skills indicators at the first meeting of the 4 indicators of students' mathematical literacy skills have not been achieved, this can explain that in general, students' mathematical literacy skills have not been mastered. After the implementation of the learning process using the Computational Thinking-Based Calculus E-Module, students' mathematical literacy skills have improved, which is strengthened by an N-gain value per mathematical literacy skill indicator with an average score of 0.77. These results prove that the Computational Thinking-based calculus E-module can improve students' mathematical literacy skills very effectively.

This finding is in line with the results of other studies that found that the development of "e-modules with a computational thinking approach" can meet the criteria as a superior module with a validation score of 169 out of 172 (Pratama et al., 2023). This proves that the increase in students' mathematical literacy skills cannot be separated from the role of the Computational Thinking-Based Calculus E-Module. The use of Computational Thinking-Based Calculus E-Module can make students involve mathematical literacy skills in solving problems.

CONCLUSION

Through the stages of research and development of the E-module, it was concluded that the Computational Thinking-Based Calculus E-module is considered feasible to use. Among them are (1) The results of the development of Computational Thinking-Based Calculus E-module were declared valid from the validity of the e-module, which was 0.72 with a high validity category, (2) The results of the development of Computational Thinking-Based Calculus E-module, based on the results of limited trials and field trials with 84.00% of lecturer responses and 81.06% student responses categorized as very practical, and (3) Computational Thinking-Based Calculus E-Module to Improve Skills Student Mathematical Literacy is effective, based on the improvement of students' mathematical literacy skills as shown by an N-gain value of 0.74 in a limited trial with a medium category, and an N-gain value of 0.77 in a field trial with a high category. In calculus lecture activities, the use of technology to facilitate the learning process through e-modules is urgently needed, especially in today's digital era. The use of computational thinking-based e-modules in calculus courses needs to be developed in order to have a design that suits the needs and capacities of students.

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