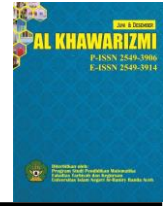




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THE DEVELOPMENT OF A REALISTIC MATHEMATICS EDUCATION (RME)-BASED E-MODULE FOR TEACHING SEQUENCES AND SERIES

Khusnul Safrina¹, Nafis Munawwarah², Rifaatul Mahmuzah³

^{1,2} Prodi Pendidikan Matematika, Fakultas Tarbiyah dan Keguruan, Universitas Islam Negeri Ar-Raniry

³ Prodi Pendidikan Matematika, Universitas Malikussaleh

khusnul.safrina@ar-raniry.ac.id

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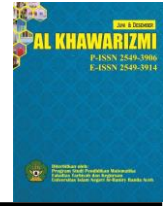
Abstrak

It is impossible to separate learning using the RME (Realistic Mathematics Education) approach from the use of learning media. However, the availability of RME-based e-modules in the learning process is still very limited, as teachers continue to rely on printed textbooks for instruction. Therefore, there is a need for more creative and innovative learning media. This study aims to develop and produce a valid and practical RME-based e-module for the topic of sequences and series. This type of research is classified as research and development (R&D) using the ADDIE model (analysis, design, development, implementation, evaluation). The subjects of this study were Grade X students at MAN 4 Aceh Besar. Data collection instruments included questionnaires, interviews, validation sheets, and teacher and student response questionnaires. The research results describe the process and outcomes of developing the e-module, which include the stages of analysis, design, development, implementation, and evaluation. The results of this study indicate that the product developed achieved a score of 83.3% in the material validation stage, which falls into the very valid category. The validation of the material's alignment with the Realistic Mathematics Education (RME) approach obtained a score of 85%, also categorized as very valid. Media validation resulted in a score of 88.1%, which is classified as very valid. Meanwhile, the practicality test conducted by teachers obtained a score of 91%, indicating that the product is very practical, while the practicality test conducted by students achieved a score of 86.7%, which is also categorized as very practical.



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INTRODUCTION

The rapid development of information and communication technology has driven changes across various sectors, including the field of education. Advances in information technology can enhance work efficiency and enable activities to be carried out quickly, precisely, and accurately. This development also impacts the demands of mathematics education. Mathematics is a core subject taught at all levels of education in Indonesia. The need for technology in education continues to increase significantly. Educators require technology to facilitate the teaching and learning process, especially in today's educational environment, which strongly emphasizes its utilization (Susanti, Safrina, K., Febriani, D.R., & Khairi, R. 2024).

In the past, society needed to perform calculations efficiently and accurately; however, nowadays, computational tasks are better handled by machines capable of performing fast and accurate calculations, even for complex mathematical content such as logarithms, statistics, trigonometry, integrals, and derivatives. Today, what is required is not merely computational skills but also the ability to reason, evaluate, analyze, communicate, and make decisions—skills that are crucial for solving various problems in this ever-changing era.

By integrating information and communication technology into mathematics learning, it is believed that the learning process can become more active, productive, and enjoyable. Moreover, it can effectively guide learning activities to achieve cognitive, affective, and psychomotor goals to their fullest potential (Supianti, 2018).

Modules play an important role in the learning process. A module is a teaching material in written or printed form that is systematically arranged, containing material, step-by-step instructions, learning objectives based on basic competencies, and guidelines for learning activities (Haristah, Azka, Setyawati, & Albab, 2019). Along with the advancement of technology and communication, modules can now be presented digitally in the form of e-modules. The development of e-modules can facilitate the alignment of teaching and learning activities to become more structured, systematic, independent, and comprehensive and produce clear outcomes (Syamsuddin, N., Manik, S.S., & Safrina, K., 2024).

According to the Ministry of Education and Culture (Kemendikbud, 2017), an e-module is an electronic learning material that can be used independently, systematically organized with various learning components, providing access to hyperlinks, and can be enriched with video presentations, animations, and audio to enhance the learning experience.

E-modules have the following characteristics: (1) **Self-Instructional**: e-modules can be used and studied independently by learners; (2) **Self-Contained**: e-modules contain complete and sequential material for one unit of competency; (3) **Stand-Alone**: e-modules do not depend on other media and can be used independently; (4) **Adaptive**: e-modules possess a high degree of adaptability in line with developments in science and technology;

and (5) **User-Friendly**: e-modules are easy to use, and each instruction and material presentation supports and assists the user (Kemendikbud, 2017).

The availability of interactive e-modules that present the learning process through audiovisual elements, sound, video, and other components related to the learning material is designed to be easily understood, thereby serving as an effective learning tool (Florentina Turnip & Karyono, 2021). Teaching materials prepared by teachers to implement the subject matter should carefully consider the content of the module being taught. Meaningful learning occurs when all the content is connected to the students' daily lives.

An appropriate learning approach for the development of e-modules is Realistic Mathematics Education (RME). RME is a learning approach that focuses on real and relevant contexts for students. This approach emphasizes process skills such as discussing, collaborating, and interacting with classmates, allowing students to discover mathematical concepts independently (student inventing), as opposed to the traditional method where the teacher simply provides information (teaching telling). Ultimately, students use mathematics to solve problems, either individually or in groups. The main idea of RME is to provide students with the opportunity to rediscover mathematical concepts and ideas with guidance from adults, using realities and environments close to them as learning resources (Tantra, Widodo, & Katminingsih, 2022).

RME is an approach that focuses on reality. RME-based e-modules can be used for students because this approach begins learning from real-life situations, allowing students to connect the material with their everyday lives. RME e-modules are designed based on students' experiences, complemented with images and real-life stories related to everyday problems, making it easier for students to understand and discover mathematical concepts (Anisah, Susanta, & Djuwita, 2023).

According to Gravemeijer (Sohilait, 2021), there are five characteristics of the RME approach: (1) Context-based problems (the use of context), (2) Using models (use models, bridging by vertical instruments), (3) Student contribution (student contribution), (4) Interactivity (interactivity), and (5) Integration with other topics (intertwining).

In the topic of sequences and series, there are many applications in daily life, such as calculating population growth, determining loan installment amounts, and calculating savings and deposit interest. However, material related to these real-life situations is rarely presented in learning modules, which makes it necessary to have modules that are relevant to such contexts. On the other hand, some students face difficulties in learning sequences and series. According to Arif Hardiyanti, some of these difficulties include understanding the concept of the first term, the inability to determine the n th term of arithmetic and geometric sequences, difficulty solving problems, and confusion in distinguishing between arithmetic and geometric sequence problems (Hardiyanti, 2016).

A study conducted by Laila Safitri et al. explains that in practice, there are still issues in mathematics education that need to be addressed, as there are many real-life events related to mathematics. Currently, many students face challenges in engaging with and dominating mathematics modules. The low mathematical comprehension ability of students in Indonesia is influenced by several factors, including the teaching techniques used by teachers, who often rely on conventional strategies, especially delivering the material through lectures. Second, teachers only use printed books due to a lack of teaching materials. Third, not all students are interested in exploring the evolving learning process and instead

feel bored because learning is delivered using conventional media. As a result, students learn less effectively and efficiently in class, which affects their mastery and understanding of the material (Safitri, N., 2022).

The researchers conducted an initial observation by distributing questionnaires to teachers and interviewing both teachers and students at MAN 4 Aceh Besar. Based on the analysis of needs through the questionnaires and interviews with two teachers at the school, it was found that, in general, teachers still use printed books as their primary reference for teaching, with only a few teachers utilizing modules based on specific teaching approaches. Additionally, there are no available e-modules to support the learning process, so teachers generally still rely on school textbooks and lecture methods in teaching. E-modules based on RME for mathematics learning, particularly for the topics of sequences and series, are also unavailable. Therefore, the development of RME-based e-modules is considered important and necessary in the learning process.

The development of this RME-based e-module aims to produce a product that can help students understand the learning material and enhance their enthusiasm and interest in learning. This e-module will be designed with an attractive, innovative, and practical layout, which can be accessed digitally at any time, ensuring that it remains engaging. Additionally, the e-module will be equipped with learning videos that connect the material to real-life situations, helping students who struggle to understand the content through text alone. This e-module will also support teachers in the teaching process.

Based on the issues above, the researcher is interested in developing an e-module entitled "Development of RME-Based E-Module for Sequences and Series," which is expected to assist the learning process and serve as an alternative to enhance students' understanding of the learning material, presented with an engaging design. The novelty of this development study lies in the integration of instructional video features within the e-module, providing learners with additional support through visual and auditory explanations of the learning materials.

RESEARCH METHOD

Type of Research

This research is a development study (research and development) using the ADDIE model. This model consists of five development stages: the analysis stage, the design stage, the development stage, the implementation stage, and the evaluation stage.

Time and Place of the Research

This research was conducted during the odd semester of the 2024–2025 academic year. It took place at MAN 4 Aceh Besar and involved Grade X students.

Subject of Research

The subjects of this research were Grade X students of MAN 4 Aceh Besar, consisting of 20 students. The subjects were selected for the field trial process to test the implementation of the developed product.

Research Procedure

The product development procedure in the creation of the e-module follows the ADDIE model, in which the product is developed through systematic stages: analysis, design, development, implementation, and evaluation. The first stage in the development process was the initial needs analysis stage. The analyses conducted included curriculum analysis and analysis of the e-module to be developed. The purpose of this stage was to determine whether the development of the e-module was necessary and to ensure that the e-module met the required criteria. This was achieved by identifying a product that was appropriate for the students, aligned with the learning objectives, relevant to the instructional content, and suitable for the learning environment. The second stage was the product design stage, which began with the initial design and development planning of the product. The final outcome of the design stage was a storyboard (media design blueprint). The storyboard serves as a guide that can be used to direct the development process of the instructional materials. It provides a structured overview of the content, layout, and learning activities, ensuring that the e-module is developed systematically and in accordance with the intended learning objectives. The third stage was the development phase. In this stage, the storyboard designed during the previous design phase was transformed into a complete e-module. Various resources required for the e-module, such as audio, video, images, and other media elements, were integrated and developed. After the development process was completed, the e-module was evaluated by expert validators to obtain feedback regarding its quality, content, and usability. The feedback provided by the validators was then used to revise and improve the e-module before proceeding to the next stage. The implementation stage involved testing and applying the newly developed product to students to determine its feasibility and adequacy for use in the learning process. This stage aimed to evaluate whether the e-module could be effectively utilized by students and whether it met the expected learning objectives and user requirements. The results obtained during the implementation phase provided valuable information regarding the practicality and effectiveness of the product in a real learning environment. At the evaluation stage, the researchers reflected on and reviewed the entire development process to identify aspects of the product that required improvement. Revisions were made based on findings from the analysis, design, development, and implementation stages. The purpose of this stage was to refine and enhance the quality of the e-module, ensuring that it effectively met the intended learning objectives and user needs.

Data Sources, Instruments, and Data Collection Techniques

The data sources in this research consist of assessment scores from validators as well as practicality evaluations from teachers and students who tested the developed module product. The research instruments include a validation sheet and a practicality sheet. These instruments were previously validated by two experts to ensure their appropriateness for use in the data collection process.

Data on the validity of the developed product were collected through a validation assessment using validation sheets evaluated by subject matter experts and media experts. Additionally, practicality data were collected through practicality sheets completed by teachers and students.

Data Analysis Techniques

The data analysis techniques used in this research include the analysis of validation sheets and the analysis of product practicality. To calculate the validity and practicality levels, the following formula is used: (Sa'dun Akbar, 2013).

$$V_a = \frac{TS_e}{TS_h} \times 100\%$$

Description:

V_a : Expert Validation Score

TS_e : Total empirical score

TS_h : Total maximum score expected

To determine the overall combined score, the following formula can be used:

$$V = \frac{\sum_{i=1}^n V_{ai}}{n} = \dots \%$$

Description:

V : Combined Validation

V_{ai} : Validation from each validator

n : Number of validator

Once the results of the combined validation analysis are obtained, the validity of the e-module can be determined using the following validity criteria:

Tabel 1. Criteria for Validity Assessment

Validity Criteria (%)	Validity Level
80-100	Very Good: Can be used without revisions.
60-80	Good: Can be used but requires minor revisions.
40-60	Fair: Not recommended for use as major revisions are needed.
20-40	Poor: Should not be used.
0-20	Very Poor: Should not be used.

Source: Adapted from Sa'dun Akbar

The practicality criteria can be seen in the following table:

Table 2. Criteria for Practicality

Practical Criteria (%)	Level of Practicality
80-100	Very Practical
60-80	Practical
40-60	Fairly Practical
20-40	Less Practical
0-20	Not Practical

Source: Adapted from Sa'dun Akbar

RESEARCH RESULT AND DISCUSSION

Research Result

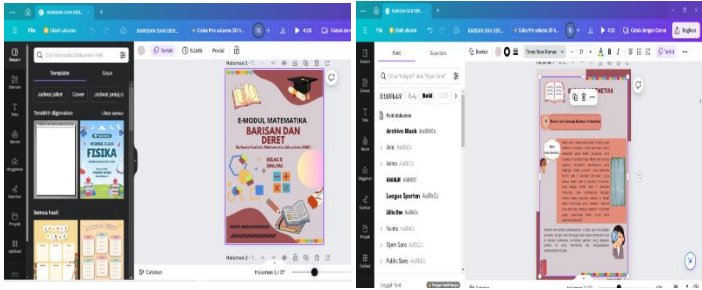
The results of the development of the RME-based e-module for sequences and series were classified as highly valid based on the assessment from validators, which was obtained from the calculation of the questionnaire data completed by the validators, and also based on the criteria table from Sa'dun Akbar, which met the very valid criteria. The assessment of the RME-based e-module, in terms of practicality, was categorized as highly practical and can be used as a learning medium. This result was obtained based on the interviews and questionnaires completed by both teachers and students.

The analysis done by the researcher at MAN 4 Aceh Besar shows that teachers mainly use textbooks for teaching, and there are no e-modules available, especially on sequences and series using Realistic Mathematics Education (RME). In the analysis of student characteristics, it was found that students are less interested in learning because the textbooks mainly contain written text, making it difficult for them to understand the material being taught. However, the learning environment at MAN 4 Aceh Besar is already equipped with comprehensive facilities, making it highly feasible to implement technology-based learning. Therefore, there is a need for an e-module that can serve as an alternative tool for teachers in teaching and as a medium to increase student engagement in learning.

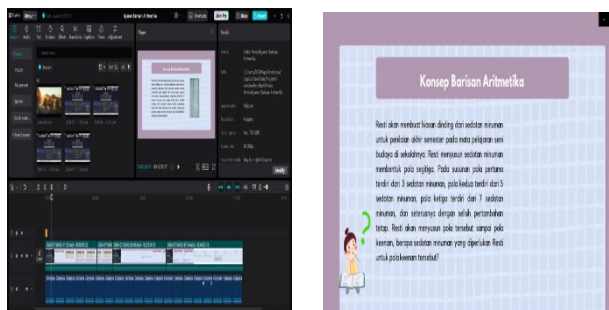
In the design phase, the researcher developed the e-module framework as attractively as possible based on the results of the previous stages. The initial step in composing the content of the e-module involved reviewing various references from books and modules related to the topic of sequences and series based on Realistic Mathematics Education (RME). The material was then structured to align with the learning objectives and expected learning outcomes. Prior to this, the developer had outlined the structure of the RME-based e-module on sequences and series, which includes a discussion of the material in each sub-topic, example problems, instructional videos, quizzes, and, upon completion of all materials, an evaluation section consisting of multiple-choice questions and a learning reflection. The questions in the e-module were not entirely sourced from textbooks; several were created and modified by the researcher.

The e-module design process involved the addition of background colors, placement of learning materials, example problems, instructional videos, quiz questions, evaluation questions, and learning reflections. Several screenshots illustrating the e-module development process can be seen in Table 4.2 below:

Table 3. E-Modul Development Process

No	Process	Picture
1	The e-module development process was carried out using the Canva application	- The process of designing the e-module cover 

- 2 The process of creating instructional videos - The process of editing instructional videos using CapCut



- 3 The process of developing the e-module using the Liveworksheets application - The process of creating quiz/practice question links



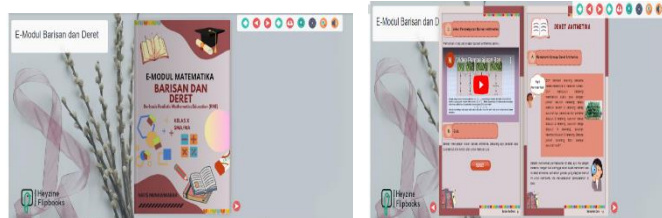
- 4 The process of developing the e-module using the Padlet application - The process of creating learning reflections



- 5 The process of developing the e-module using the Heyzine application - The process of combining into the e-module



- 6 The result of developing the e-module using Canva, Liveworksheets, Padlet, and Heyzine - The cover design and layout of the e-module



Next, the results of the development phase are presented through the expert validation data. The validation data of the e-module on the topic of sequences and series for Phase E, Grade X of Senior High School/Madrasah Aliyah, as assessed by the validators, has been calculated as an average for each validator. The e-module validation data from two subject matter expert validators was analyzed by the researcher. The analysis indicated that the content and material presented in the e-module were deemed appropriate and easily understandable by students. For the assessment criteria, the opening section received a percentage score of 86.7%, the content section received 82.5%, and the closing section received 83.3%.

In addition, the validation score in terms of alignment with Realistic Mathematics Education (RME) was 85%, categorized as highly valid. Therefore, it can be concluded that the e-module is appropriate and feasible for use from the perspective of RME alignment. However, the e-module will still be revised in accordance with the suggestions provided by the validators.

Table 4 Validation Results by V1 and V2 Regarding Compliance with the Realistic Mathematics Education (RME) Principles

No	Kriteria Penilaian	Validator		Percentage
		V1	V2	
1	Kesesuaian materi dalam <i>e-modul</i> dengan pendekatan RME	4	4	80%
2	Kesesuaian materi yang disajikan dengan tahap <i>mathematical world orientation</i>	4	5	90%
3	Kesesuaian materi yang disajikan dengan tahap <i>material model</i>	4	4	80%
4	Kesesuaian materi yang disajikan dengan tahap <i>building mathematical relationship</i>	4	4	80%
5	Kesesuaian materi yang disajikan dengan tahap <i>formal notation</i>	4	5	90%
6	Permasalahan yang diberikan merupakan permasalahan nyata	4	5	90%
Total Skor		24	27	85%
Skor Validasi		80%	90%	85%

The e-module validation data from two media expert validators showed the following results: the design aspect received a percentage score of 86.7%, the layout appropriateness aspect received 90%, the image presentation appropriateness aspect received 90%, the font type and size appropriateness aspect received 86.7%, the color combination appropriateness aspect received 85%, the illustration aspect received 80%, the sentence structure and language usage aspect received 90%, the ease of operation aspect received 95%, and the usefulness for learning aspect received 90%.

Next, the results of the practicality testing of the Realistic Mathematics Education (RME)-based e-module on the topic of sequences and series showed a percentage of 86.7%, categorized as highly practical. This indicates that the RME-based e-module on sequences and series is deemed suitable for use.

Discussion

The discussion is based on the stages of the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The analysis stage is the initial phase in the e-module development process. This stage explains the results of needs analysis in developing a new product, such as a model, method, media, or teaching material, as well as assessing the feasibility and requirements for developing the product. Product development often starts due to issues with existing products or implementations. These problems may arise because the current product is no longer relevant to the needs of the target audience, learning

environment, technology, student characteristics, and other factors (Maydiantoro, 2020). In this case, product development, such as the development of e-modules, is highly needed in education as it can align the learning process with the current technological advancements.

Based on the results of the initial analysis conducted by the researcher at MAN 4 Aceh Besar, it was found that teachers generally still use textbooks as the primary medium in the learning process and that there is no e-module available, especially an RME-based e-module for sequences and series. In the analysis of student characteristics, it was found that students are less interested in learning because the textbooks only contain written text, making it difficult for students to understand the material being taught. From the perspective of the learning environment, MAN 4 Aceh Besar already has very complete facilities, making it highly feasible to implement learning utilizing technology.

This is supported by a study conducted by Rieke Alyusfitri, which found that teachers rely solely on textbooks and student worksheets (LKS) in teaching and have limited understanding of the use of technology. As a result, the learning process becomes monotonous and boring, making it difficult for students to grasp the concepts being taught. In addition to the limited teaching materials, there is also a lack of teaching materials in the form of e-modules (Alyusfitri, Sari, Jusar, & Pratiwi, 2023). Based on these issues, the researcher initiated a renewal process for the teaching materials used by teachers and students at the school by developing a mathematics e-module as a solution to these problems. Based on these issues, the researcher initiated a renewal process for the teaching materials used by teachers and students at the school by developing a mathematics e-module as a solution to these problems.

In the design stage, the product design is carried out, which involves creating an RME-based e-module design for the topic of sequences and series. The designed e-module must align with the components that are typically found in an e-module.

The components included in the e-module are: 1) cover page, 2) preface, 3) table of contents, 4) introduction, which includes a brief description of the e-module, learning guide, learning outcomes, and learning objectives, 5) concept map, 6) RME-based sequences and series material, student activities, sample problems, and quizzes/exercises, 7) summary, 8) evaluation questions, 9) learning reflection, and 10) references. This e-module is designed with material directly related to real-life situations, which can help students understand the content and serve as a medium that facilitates both teachers and students in the learning process.

The development stage involves the validation process of the developed e-module. This content process involves 6 validators who act as experts in the fields of content and media. The validators are provided with validation sheets to assess each aspect of the evaluation that has been prepared. The valid criteria from the experts are obtained through the validation sheets for teaching materials, which cover four components: content feasibility, language, presentation, and graphics. This refers to the opinion of Pudji Muljono in the BSNP Bulletin (Ansori et al., 2022). The e-module developed by the researcher meets the level of validity as explained in the previous description.

The validation results from the experts (validators) show that the developed e-module falls under the "very valid" criteria, with a percentage of 83.3%, and is deemed suitable for use in terms of content completeness and feasibility. The assessment of the

validity in terms of the e-module's function as a medium also shows very valid results with a percentage of 88.1%.

This stage is the product trial phase to assess the practicality of the developed product, which will be tested on teachers and students by providing a practicality sheet. It also includes the implementation phase of the developed media on a larger scale. The implementation stage is carried out by distributing the final product, which is the RME-based e-module, to teachers and students at MAN 4 Aceh Besar.

According to Rochmad, the practicality aspect from the user's perspective includes two factors: (1) the opinions of experts and practitioners on whether the developed product can be used under normal conditions, and (2) the reality of whether the product can be implemented by teachers and students. A product is considered practical if experts and practitioners state that, theoretically, the model can be applied in the field and the level of implementation is categorized as "good." The term "good" needs to be measured with the necessary indicators to determine the level of practicality in applying the model. Based on this opinion, the e-module developed by the researcher meets the level of practicality and feasibility for use (Rochmad, 2012)

The level of practicality of the module's use is tested through implementation in field trials. The practicality percentage calculated by teachers yielded a positive value of 91%. The practicality criteria for the e-module from the teachers are categorized as very practical for further use. Meanwhile, the practicality percentage from students was 86.7%. The practicality criteria from students are also considered very practical. Therefore, it can be concluded that this e-module product is suitable for use.

The final stage is the evaluation phase. In this stage, the researcher assesses whether the developed product meets the criteria of validity and practicality and is suitable for use in the learning process. The evaluation phase involves assessing each of the four preceding stages-analysis, design, development, and implementation-referred to as formative evaluation. A limitation of this phase is that summative evaluation, which is the final stage of evaluation used to determine the effectiveness of the developed product, was not conducted.

CONCLUSION

The conclusion of the study, based on the results and discussion presented earlier, is that the development process of the RME-based e-module for the topic of sequences and series, using the ADDIE development model, generally proceeded well. The developed e-module product falls within the highly valid criteria (85% and 88,1%) . Furthermore, the practicality level of the e-module is classified as highly practical (91%).

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