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DEVELOPMENT OF AN INTERACTIVE FLIPBOOK-BASED E-MODULE TO ENHANCE STUDENTS' ABILITY TO UNDERSTAND MATHEMATICAL CONCEPTS IN ARITHMETIC SEQUENCES AND SERIES

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Abstract

This study addresses the challenges in the learning process, particularly the reliance on textbooks and limited instructional materials, leading to low mathematical conceptual understanding among students, especially in arithmetic sequences and series. To tackle this issue, an interactive flipbook-based e-module was developed to enhance students' conceptual understanding. The aim of this study is to create valid, practical, and effective teaching materials in the form of this e-module. Using the ADDIE development model, the research comprises five phases: Analysis, Design, Development, Implementation, and Evaluation. Data analysis techniques include tests for validity, practicality, and improvements in conceptual understanding. Validity analysis yielded scores of 92.36% from media experts and 87.84% from content experts, both classified as "very valid." Practicality analysis resulted in a score of 78.33% from teacher responses (categorized as "practical") and 81.56% from student responses (categorized as "very practical"). The e-module successfully enhances conceptual understanding, with average pretest and posttest scores of 16.91 and 23.04, respectively. N-Gain analysis indicates an average N-Gain score of 0.88, classified as "high." In conclusion, the developed interactive flipbook-based e-module is valid, practical, and effective in improving students' mathematical conceptual understanding.

Keywords: Arithmetic sequences and series, conceptual understanding, e-module, interactive flipbook.

Abstrak

Penelitian ini didasarkan pada permasalahan proses pembelajaran yang masih menggunakan buku paket dan belum bervariasi dalam memanfaatkan bahan ajar serta rendahnya pemahaman konsep matematis siswa khusunya pada materi barisan dan deret aritmatika. Sebagai alternatif dikembangkan e-modul berbasis flipbook interaktif untuk meningkatkan kemampuan pemahaman konsep matematis siswa pada materi barisan dan deret aritmatika. Penelitian ini bertujuan untuk mengembangkan bahan ajar berupa e-modul berbasis flipbook interaktif materi barisan dan deret aritmatika yang valid, praktis dan meningkatkan kemampuan pemahaman konsep matematis. Jenis penelitian ini merupakan penelitian pengembangan dengan model ADDIE dengan lima tahap, yaitu Analysis, Design, Development, Implementation, and Evaluation. Teknik analisis data yang digunakan yaitu uji kevalidan, uji kepraktisan, dan peningkatan pemahaman konsep matematis. Hasil analisis kevalidan dari ahli media memperoleh nilai sebesar 92,36% dengan kriteria "sangat valid" dan dari ahli materi yaitu 87,84% dengan kriteria "sangat valid". Hasil analisis kepraktisan e-modul ditinjau dari respon guru memperoleh nilai sebesar 78,33% dengan kriteria "praktis" dan ditinjau dari respon siswa memperoleh nilai sebesar 81,56% dengan kriteria "sangat praktis". E-modul ini berhasil dalam meningkatkan kemampuan pemahaman konsep, hal ini diperoleh nilai rata-rata pretest sebesar 16,91 dan nilai rata-rata posttest sebesar 23,04. Berdasarkan hasil analisis data uji N-Gain hasil peningkatan pemahaman konsep matematis dengan nilai rata-rata N Gain sebesar 0,88 dalam kriteria "tinggi". Berdasarkan penjelasan di atas, disimpulkan bahwa e-modul berbasis flipbook interaktif yang dikembangkan valid dan praktis dalam meningkatkan pemahaman konsep matematis siswa.

***Kata kunci**: Barisan dan deret aritmatika, e-modul, flipbook interaktif, pemahaman konsep.*

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INTRODUCTION

Mathematics is a subject that requires focused thinking to recall and remember the material learned, enabling students to master the concepts (Hadi & Kasum, 2015). However, many students find it difficult to study mathematics, resulting in a lack of understanding of mathematical concepts. Research on students' conceptual understanding shows that their grasp of mathematical concepts is still relatively low (Hoiriyah, 2019).

The ability to understand mathematical concepts is reflected in a study conducted by Zebua (2020), which analyzes students' errors in solving sequence and series problems based on their conceptual understanding. Hartati's research (2021) indicates that students still face difficulties in solving arithmetic sequence and series problems, including: 1) students not understanding the concepts of sequences and series, 2) difficulties in calculating exponential multiplications, and 3) challenges in distinguishing between sequences and series. Based on tests administered on sequences and series to students at SMA Negeri 2 Kuningan, many students struggle to differentiate between the two, leading to errors in determining the correct formulas for answering problems. Some students resort to counting each term individually, which can be time-consuming.

Given these issues, teachers need to strategize their delivery of mathematical material, which could involve selecting engaging instructional media that actively involve students in the learning process, thereby enhancing their conceptual understanding.

In line with globalization and technological advancement, the rapid use of information technology has become evident. One implementation of this technology is the use of technology-based modules, known as e-modules. E-modules are electronic versions of printed modules that can be read on computers and designed with necessary software. Electronic modules can display images, animations, texts, and videos through electronic devices (Rahman, 2022). One learning media that can be applied is a flipbook-based learning module (Sari & Khaidir, 2023)

Flipbooks are a technological application that can be used to design and create engaging electronic learning modules. They can be presented interactively, combining images, sounds, text, and videos to create an engaging learning experience that encourages student interaction (Rahadhian et al., 2022). The appealing design of flipbooks is novel and helps spark students' interest in learning mathematics (Niam et al., 2022). According to research by Rahadhian et al. (Rahadhian et al., 2022), flipbook learning media serves as an alternative solution to support student learning in the era of Industry 4.0, providing visually and audibly engaging content, meanwhile, provious studies focused on the general development of flipbooks and on other subject areas. They did not specifically examine whether interactive flipbooks can improve students' conceptual understanding of mathematics in the topic of arithmetic sequences and series. In addition, earlier researchers have not thoroughly assessed the validity, practicality, and effectiveness of flipbooks through N-Gain analysis for the topic of arithmetic sequences and series.

Therefore, the researcher intends to provide an update by developing an interactive flipbook-based e-module that is not only visually appealing but also tested for its validity, practicality, and effectiveness in improving students'

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conceptual understanding of mathematics in the topic of arithmetic sequences and series, which has not been widely studied previously.

METHODS

The type of research conducted is Research and Development (R&D). The R&D model is a research method used to produce specific products and test the effectiveness of those products. The material studied in this research is arithmetic sequences and series .

The subjects of this research are 23 students from class XI of SMA Negeri 2 Kuningan who participated in the pretest and posttest. The research was conducted during the second semester of the 2023/2024 academic year in class XI at SMA Negeri 2 Kuningan, located at Jalan Aruji Kertawinata No. 16 Kuningan.

The research activities took place on March 27-28, 2024. This study employs the ADDIE development model, developed by Dick and Carey (1996), to design the learning system. This model consists of five main stages or phases: (1) Analysis, where the stage begins with identifying issues in the current learning model/method. The aspects analyzed include curriculum analysis and needs analysis; (2) Design, which involves creating the material design, layout, and other instruments that will be used in the development phase. The material design is aligned with the analysis results, determining the flow of learning in the presentation of the material; (3) Development, which consists of realizing the product design. This stage also tests the feasibility level of the product; (4) Implementation, where the developed design is implemented or tested in real situations, namely in the classroom, while assessing the practicality of the product; and (5) Evaluation, which involves analyzing the quality, feasibility, practicality, and conducting N-Gain tests.

The data collection techniques used in this study consist of several instruments, each accompanied by specific data collection procedures. The test instruments used to measure students' conceptual understanding through pretest and posttest assessments. The questionnaire instrument is administered to teachers and students to examine the practicality of the e-module based on practicality indicators. The validation sheets are completed by media experts and material experts to assess the validity of the e-module according to predetermined validity criteria. Lastly, interviews and observations are conducted to obtain qualitative data that support the interpretation of the test and questionnaire results. The improvement analysis is based on the results of the students' pretest and posttest using the N-Gain test.

The data analysis techniques in this study are divided into qualitative and quantitative analyses. Qualitative data are descriptive, which can include critiques, comments, and suggestions from validators, which are used to revise and improve the e-module. Quantitative data consist of numerical scores and percentages of the research results. The data analysis techniques used in this study include validity analysis, practicality analysis, and improvement analysis (N-Gain Test). Each instrument used in this study has a corresponding analysis technique, including:

Validity Analysis

The validation sheets consist of material expert validation and media expert validation. The validators' assessments are calculated into percentage form and then interpreted based on predetermined validity criteria.

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Practicality Analysis

The practicality questionnaires are completed by teachers dan students. The percentage of their responses is calculated and then categorized according to practicality criteria.

Improvement Analysis (N-Gain)

This analysis examines students' conceptual understanding using the N-Gain formula based on pretest and posttest scores. The N-Gain values are interpreted according to standard criteria.

The success indicators in this study are: the validity score must fall into the "valid" or "very vali" category, the practicality score must fall into the "practical" or "very practical" category, and the N-Gain value must fall into the "medium" or "high" category.

RESULTS AND DISCUSSION

This research utilizes the ADDIE model, which is structured into a series of distinct stages (Spatioti et al., 2022). Each phase plays a critical role in guiding the development and implementation process:

Analysis

The analysis stage of this study involves analyzing the issues that occur at SMAN 2 Kuningan. The aspects analyzed include curriculum analysis and needs analysis.

The purpose of the curriculum analysis is to align the developed e-module with the implemented curriculum. In the curriculum analysis, activities include identifying development materials that are tailored to the syllabus and analyzing characteristics by reviewing the applicable syllabus (Adesfiana et al., 2022). Meanwhile, the needs analysis aims to gather data on the issues experienced by teachers and students. The needs analysis includes identifying problems, identifying instructional materials suitable for students, and designing the developed instructional materials (Nindiawati et al., 2021). Information obtained from observations and interviews with the mathematics teachers of class XI reveals that the issues in the learning process still involve using textbooks as the main learning resource and not utilizing electronic learning media. The learning method employed is primarily lecture-based. Additionally, students struggle to understand the material, especially regarding sequences and series. They are confused about using the formulas for both arithmetic sequences and arithmetic series. This issue mirrors the findings of Zebua (Zebua, 2020), indicating that students are unable to determine the correct formula to solve problems, as they cannot differentiate between arithmetic and geometric sequences, leading to errors in answering questions.

Design

This stage involves the creation or design of an e-module focusing on arithmetic sequences and series, aligned with the results of the analysis stage. This stage produces a conceptual product design that will inform the development process in the subsequent stages (Rusmayana, 2021). Several activities are conducted during this stage, including: (1) compiling learning materials on arithmetic sequences and series in accordance with core competencies (KI) and basic competencies (KD), (2) gathering components such as images, videos, and other materials, (3) designing the e-module, which provides an overview of the relationships between sections within the e-module, particularly the material to be discussed, (4) collecting

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and creating the background, cover, and layout, (5) structuring the e-module framework to serve as a guideline during e-module compilation, and (6) developing validation instruments for the e-module's feasibility, starting with preparing the grid and the questionnaire.

Development

This stage involves the realization of the product design. It also tests the product's feasibility or validity assessment. In line with Rusmayana's (Rusmayana, 2021) research, the development stage includes activities for realizing the product design previously created. The objective of this stage is to produce a draft revision of the instructional materials based on expert feedback, which can then be tested (Yuliastuti & Soebagyo, 2021). The interactive flipbook-based e-module undergoes validation to measure the validity of the developed e-module. This validation is conducted by five validators, including two media experts and three content experts. Figures 1 and 2 illustrate the appearance of the developed module.

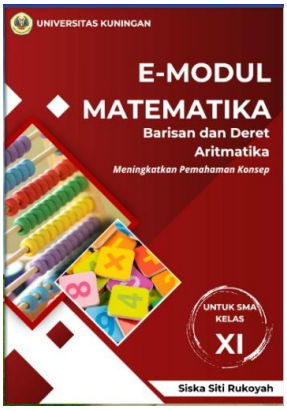

Figure 1. E-module Cover Page

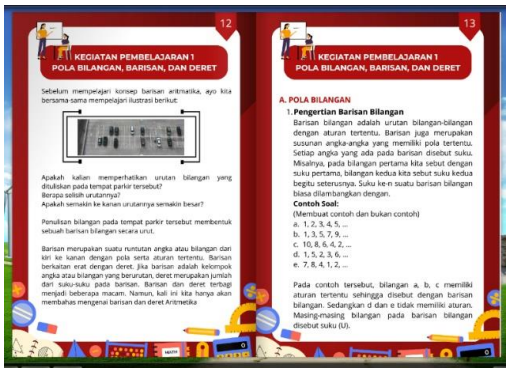

Figure 2. Material Display in the E-module

Figure 3. E-module QR Code

Media expert validation was conducted by 2 validators from Kuningan University. This media expert validation consists of 3 aspects: visual aspects, programming aspects, and language aspects. All aspects consist of 14 statements. The data from the media expert validity test can be seen in Table 1.

Table 1. Results of media expert validation assessment

No	Assessment Aspect	Percentage	Criteria
1	Display	93,75 %	Very valid/ very good
2	Programming	83,34 %	Very valid/ very good
3	Language	100 %	Very valid/ very good
	Total	**92, 36 %**	**Very valid/ very good**

Based on the validation percentage results, the average score was **92.36%** under the **'very valid/very good'** criteria, indicates that the media

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expert validators assessed the e-modul as having very good quality and suitable for use in the learning process. The means that the display, programming, and language aspects are considered effective in supporting conceptual understanding and student engagement.

The e-module should have an appealing design, appropriate color use, clear text, relevant images, animations, audio, video, and other elements to help students easily understand the e-module. This aligns with the research by (Fatmawati et al., 2024), which states that an e-module with appealing visuals, supported by relevant video and audio, enhances understanding of the material.

The programming aspect assesses the quality of the e-module by evaluating the user instructions, navigation, and smooth operation. Research by (Sari & Khaidir, 2023) explains that the Flipbuilder e-module is easy to use, allowing page-flipping by simply swiping left or right and clicking the provided icons.

The language aspect is examined to ensure the language and sentences used follow standard Indonesian language rules (EYD). This aspect helps guarantee the clarity of the conveyed information. This is consistent with (Engelbrecht & Borba, 2024), who found that media developed under the 'very valid' criteria have clear information, use correct language, and feature simple, clear, and easily understandable sentences.

Content expert validation was conducted by 3 validators: 1 mathematics teacher from SMAN 2 Kuningan and 2 lecturers from Kuningan University. This content expert validation consists of 2 aspects: the accuracy of material concepts and content feasibility, and the instructional aspect. All these aspects consist of 16 statements. The results of the content expert validity test is presented in Table 2.

Table 2. Results of content expert validation assessment

No	Assessment Aspect	Percentage	Criteria
1	The correctness of the material concepts and the feasibility of the content	90, 27 %	very valid/very good
2	Learning	85,41%	very valid/very good
	Total	**87,84%**	**very valid/very good**

Based on the results of the material expert validation percentage, an average score of **87.84%** was obtained, indicating that the material expert validators assessed the e-module in terms of conceptual accuracy and content feasibility as highly accurate, well-structured, and strongly supportive of students' conceptual understanding, thus it is categorized as "very valid/very good".

The aspects of the correctness of the material concepts and the feasibility of the content both fall into the 'very valid/very good' category because these aspects indicate that the material on arithmetic sequences and series presented in the interactive flipbook-based e-module is aligned with the core competencies (KD), indicators of learning achievement (IPK), learning objectives, and the curriculum used. The selection of problems and examples provided is appropriate for conceptual understanding. The presentation of the material is orderly or systematic and

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correct. This aligns with the characteristics of the e-module, where all the material from a single competency unit is comprehensively included in the e-module (Sinaga, 2023).

The learning aspect, which is also categorized as 'very valid/very good,' is evidenced by the clear instructions for using the e-module. The flipbook-based e-module can provide feedback or motivation for students' learning, offer opportunities for independent study, and positively impact students' creativity. This is also based on the understanding that the e-module is a systematically arranged independent learning resource in electronic format, which can include animations, audio, and navigation (Nurhikmah et al., 2021).

Based on the validation conducted with media expert validators and material expert validators, the suggestions and feedback from media and material validators can be seen in Table 3.

Table 3. Suggestions and feedback from media and material expert validators

No	Validator's Name	Suggestions and Feedback
1	Erlan Darmawan, S.Kom., M.Si., Ph.D.	• The writing structure is still ambiguous and needs to be revised. • The design and color are very good.
2	Heru Budianto, S.ST., M.Kom.	• In the conclusion, it is recommended to include a more detailed explanation of the content of the module. • The back page should include a brief synopsis of the e-module.
3	Hj. Lina Marlina, S.Pd.	• This flipbook-based e-module is quite good, but it needs improvement in solving problems. • Provide explanations for practice questions so that students can learn independently.
4	Dr. Arrofa Acesta, S.Pd., M.Pd.	• The cover design should be changed to "Mathematics E-module," and it should be stored near the 11th-grade classroom. • Instructions for using the application should be enhanced. • Quizzes must include feedback and an introduction.
5	Dr. Anggar Titis Prayitno, S.Si., M.Pd.	• The currency unit on page 33 should be written as Rp. • The font size should be made consistent. • On page 9, in instruction no. 8, it should say "At the end ...".

Implementation

This stage involves validating the practicality questionnaire with the mathematics teachers and students of class XI Mipa 1 at SMAN 2 Kuningan, as well as implementing the e-module alongside conducting pretests and posttests. The implementation stage is carried out by testing the developed mathematics e-module during the development phase to assess its feasibility and practicality (Jamaan & Yerizon, 2023).

The practicality validation based on teacher responses consists of 3 aspects: the quality of content and

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objectives, technical quality, and learning quality. All aspects include 10 questions. Table 4 presents the results of the practicality test based on teacher responses.

Table 4. Results of the E-module Practicality Based on Teacher Responses

No	Assessment Aspect	Percentage	Criteria
1	Quality of Content and Objectives	85 %	Very practical/very good
2	Technical Quality	75 %	Practical/Good
3	Learning Quality	75%	Practical/Good
Total		**78, 33 %**	**Practical/Good**

Based on the percentage results of the practicality validation from teacher and lecturers responses (Table 4), an average score of **78.33%** was obtained, this indicates that teachers and lecturers assessed the e-module in terms of content and objectives quality, technical quality, and learning quality, and considered it effective and feasible for use in learning, particularly in enhancing students' conceptual understanding and supporting teaching activities.

This result aligns with research stating that the practicality of the developed product is deemed complete if the percentage meets the criteria of very practical and practical (Puteri, 2023). This indicates that the e-module is easy to use and implement in the learning process.

The quality of content and objectives assessment aspects include the clarity of instructions and ease of use; the material corresponds with SK, KD, IPK, and learning objectives; clarity of the material; and systematic presentation of the material. Meanwhile, the learning assessment aspects consist of clarity in display, color, and navigation; the e-module supports the learning process; the e-module simplifies the delivery of material; and the e-module provides opportunities for independent learning.

The practicality validation based on student responses consists of 2 aspects: display and learning aspects, as well as content and motivation aspects. All aspects comprise 9 questions. Table 5 is the results of e-module practicality based on student responses.

Table 5. Results of e-module practicality based on student responses

No	Assessment Aspect	Percentage	Criteria
1	Display and learning	85 %	Very practical/very good
2	Content and motivation	78, 12 %	Practical/Good
Total		**81, 56%**	**Very practical/very good**

Based on the percentage results of the practicality validation from the responses of 4 students in class XI MIPA 1 at SMA Negeri 2 Kuningan (Table 5), an average score of **81.56%** was obtained, this indicates that the students assessed the e-module in terms of display and learning, as well as content and motivation, and found it to be very good. The e-module is easy to use, engaging for students, and useful in supporting the learning process, particularly in enhancing conceptual understanding (Mukuka & Tatira, 2025).

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An attractive e-module display usually considers the suitability and clarity of text, images, animations, videos, and easy navigation. This aligns with research stating that media is visually appealing when supported by appropriate video and audio. The material and motivation aspects consist of assessments indicating that the e-module facilitates understanding of the material, presents material systematically, uses mathematical terms in a simple and comprehensible manner, and can motivate students.

Evaluation

This evaluation phase is conducted by examining the results of pretests and posttests consisting of 3 open-ended questions. The purpose of this evaluation is to determine whether the developed interactive flipbook-based e-module can enhance students' mathematical conceptual understanding in the material of arithmetic sequences and series.

The improvement in mathematical conceptual understanding among XI MIPA 1 students at SMA Negeri 2 Kuningan is indicated by an average pretest score of 16.91 and an average posttest score of 23.04 out of a maximum score of 24. These scores were then analyzed using the N-Gain test, resulting in a score of **0.88**, categorized as a "**high**" increase. This improvement is attributed to the attractive and interactive nature of the e-module, which includes images, educational videos, and interactive quizzes that can be filled out directly by selecting the correct answer options, thereby enhancing students' enthusiasm in the learning process (Adiastuty et al., 2024; Nurhayati et al., 2023).

The high N-Gain results are supported by interviews conducted with 2 students from XI MIPA 1 at SMA Negeri 2 Kuningan, who reported being able to distinguish between arithmetic sequences and series, as well as recognizing the mathematical symbols used in them. They also possess an understanding of the concepts of arithmetic sequences and series, even though they do not always write down specific information in the problems. They are capable of recognizing or identifying crucial information within the problems that is essential for determining the steps to answer them.

These results indicate that the interactive flipbook-based e-module is very valid and highly practical for enhancing students' mathematical conceptual understanding in the material of arithmetic sequences and series. The development of e-modules like flipbooks can help improve students' skills, including conceptual understanding (Sari & Khaidir, 2023; Rochsun & Agustin, 2020). Furthermore, the research also shows that the development of a mathematics e-module using interactive software yielded good results for use in the learning process, his study refers to the investigation of good teaching practices and approaches in relation to the ADDIE model in distance online environments (Spatioti et al., 2022).

CONCLUSION AND SUGGESTION

The product of this research development is an interactive flipbook-based e-module aimed at enhancing students' mathematical conceptual understanding in the material of arithmetic sequences and series. Based on the research results, it can be concluded that: (1) The interactive flipbook-based e-module developed

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using the ADDIE model (analysis, design, development, implementation, and evaluation) has been proven to valid, practical, and capable of enhancing students' conceptual understanding. (2) The validity assessment by media and subject matter experts resulted in a score of 90,21% "very valid", and the practicality assessment based on teacher and student responses resulted in a score of 80,97% "very practical". (3) The N-Gain test showed a score of 0,88 indicating that the e-module effectively improves students' mathematical conceptual understanding in arithmetic sequences and series, categorized as high. These results indicate that the interactive flipbook-based e-module developed is a feasible and effective learning resource, capable of supporting teaching activities and enhancing students' mathematical conceptual understanding.

The following suggestions are offered for the future development of the e-module. Currently, the quizzes in the e-module lack explanations for incorrect answers, so adding explanations, such as through video tutorials, could help students understand their mistakes. In addition, the e-module requires internet access to be used, so future researchers may consider developing an offline-accessible version. Furthermore, the use of crossword puzzles is less interactive as they cannot be completed directly within the e-module. Therefore, providing crossword puzzles that can be accessed via links or QR code scanning could enhance student engagement and interactivity.

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