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Development of Flipbook-Interactive Modules: Improving Understanding of Basic Electrical Concepts

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ABSTRACT

Purpose – This research aims to develop an interactive e-module based on a flipbook to improve understanding of basic electrical concepts.

Methodology – The methodological approach in this study uses the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The methods used include needs analysis, design, and evaluation, focusing on improving student interactivity and learning outcomes through the attractive Flipbook application. The sample of this study is 80 students of Electrical Engineering Education at the State University of Surabaya, which was obtained through purposive sampling techniques. The data collection procedure is in the form of a questionnaire to find out the responses of validators and students to the interactive e-module and provide multiple-choice questions to measure learning outcomes.

Findings – The study results show that the flipbook-based e-modules developed have high validity, with assessments from subject matter experts and media experts achieving an average score of 88.7%, with a very valid category. In addition, this e-module has also proven to be practical and effective in improving students' understanding of basic electrical concepts. The results of the assessment of student responses in the large group trial obtained an average percentage of 90% in the excellent category. The trial results showed increased student learning outcomes, averaging 82.6 in the effective category.

Contribution– This research significantly contributes to the development of learning media in accordance with the current development of educational technology. Using this e-module can increase students' interest and motivation to learn and provide a more interesting and interactive alternative learning medium.

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INTRODUCTION

A strong conceptual understanding is a crucial foundation for Electrical Engineering students, especially in mastering the basic concepts of electricity at the core of various engineering applications. Concepts such as voltage, electric current, resistance, and relationships between variables are often considered abstract and challenging to understand by most Electrical Engineering students. This is exacerbated by using conventional methods that lack interactivity and visualization, making the learning process less interesting and meaningful (Mardianti et al., 2023) (Adonis, 2024).

The urgency of this research is very high, considering the importance of research that focuses on the development of interactive learning media for Basic Electricity. The development of this learning media is to improve students' understanding and skills. Learning media is not just a tool, but an important part of a teaching strategy that aims to improve the quality of student understanding, engagement, and learning outcomes (Degner et al., 2022). Students' low understanding impacts difficulties in solving reasoning-based problems and limitations in relating concepts to daily life phenomena (Waluyo & Wahyuni, 2021). Without a solid understanding, students will have difficulty taking advanced courses and face challenges in the world of work.

As a result of needs assessments, observations, and interviews with Electrical Engineering students at the State University of Surabaya in 2024, students' knowledge and understanding of basic electricity is still low. This can be seen from their difficulty in applying theory to practical problems, frequent misconceptions about electrical phenomena, and low ability to analyze complex electrical circuits. Teaching styles that tend to be one-way and lack interactive learning media are allegedly the main factors that worsen this condition. As a result of discussions with Electrical Engineering lecturers, one of the leading causes of this problem is the use of learning media that are less interactive and non-contextual. The material is delivered textually and monotonously, lacking the dynamic visualization that could clarify the flow of concepts and relationships between variables in electrical science learning. As a result, students tend to memorize formulas without really understanding the conceptual meaning of electrical science behind them. In line with Villasmil (2024), Innovative learning media support is needed to improve students' theoretical skills and practical applications in daily life.

A solution to this problem is to integrate technology into electronic modules (e-modules). Educators must understand the needs of students in the digital age and master and adapt technology (Syahbaruddin et al., 2023). Students are conditioned for real and meaningful learning. Educators must have a professional level that can carry out teaching and learning activities and understand the demands of the quality of educators' digital competencies in designing teaching materials (Sarip et al., 2024). The development of technology integration in education, which is becoming increasingly sophisticated, encourages innovation in learning media development (Dasmo et al., 2025).

One of the learning innovations developed is Flipbook-based electronic modules, which offer an interactive and flexible learning experience. A flipbook is an Interactive digital media in the form of digital books or e-books that present content, allowing users to digitally "flip" pages (Subiyakto et al., 2024). Using flipbooks in the e-module allows the presentation of materials with a combination of text, images, audio, and video, so that it can meet a variety of students' learning styles. According to Yuliasari & Elizabeth (2023), developing a flipbook e-module can improve the understanding of vocational school students, which shows positive results in improving student understanding. In addition, developing flipbook-based e-modules that are considered feasible and effective in learning can improve students' critical thinking skills (Darmawan et al., 2024).

The expected impact of the development of this module is a significant improvement in the conceptual understanding of basic electrical concepts of Electrical Engineering students of Unesa, which in turn will improve academic performance and readiness of students to face professional challenges. Previous research findings stated that electronic modules using a problem-solving model equipped with HOTS questions are suitable as independent teaching materials and can improve students' high-level thinking skills (Astra et al., 2020)—the use of HOTS-oriented e-modules in learning electrical circuits (Yusuf et al., 2020). A virtual

simulation learning model about electrical circuits can foster students' interest in learning (Darmawan et al., 2021). Development of problem-solving-based e-modules on dynamic electricity material to improve students' conceptual understanding (Azizahwati et al., 2024). Electrical and Magnet learning e-modules with mobile augmented reality to improve students' conceptual understanding (Abdillah et al., 2025).

Research that develops and evaluates e-modules for Basic Electricity is still limited. The novelty of this research lies in integrating the basic concept of electricity into the form of an interactive flipbook that is designed systematically, contextually, and based on the needs of students, which has not been developed optimally before. This innovation can be a more interesting, accessible, and conceptually in-depth learning alternative (Keedle et al., 2024). E-modules are designed to convey information and build conceptual understanding progressively through simulations, interactive exercises, and learning reflections. Thus, developing this module is expected to be a breakthrough for increasing student interactivity and learning motivation in mastering the concept of Basic Electricity.

METHODOLOGY

Research Design

This research uses the Research and Development (R&D) method with the ADDIE Model. According to Robert Maribe Branch (2009), in (Revita et al., 2024) There are stages of the ADDIE model, including: Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it is systematic and suitable for developing and testing the effectiveness of digital-based learning media.

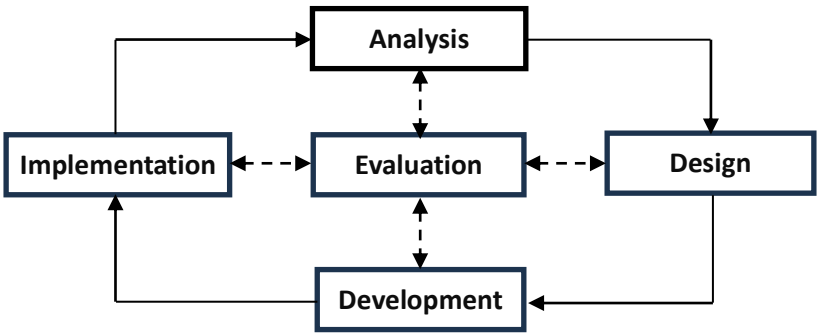

Figure 1. ADDIE Concept

The stages in the ADDIE model include: (1) Analysis: identifying learning needs, student characteristics, and constraints in learning Basic Electricity, (2) Design: designing a Flip Book-based e-module structure, including the selection of materials, interactive features, and supporting media, (3) Development: develop e-modules by utilizing Flip Book Creator software and conduct validation tests by media experts and material experts, (4) Implementation: implementing e-modules in learning and testing their effectiveness with student groups, (5) Evaluation: evaluating the results of each stage of implementation based on validation data, student response, and increased understanding of the concept of Basic Electricity.

Participants

The research sample amounted to 80 students of Electrical Engineering Education, State University of Surabaya. Samples were taken using the intended sampling technique, with consideration that the participants had a background relevant to the study.

Instrument and Data Collection

The data collection techniques obtained in this study are grouped into three assessment categories, namely: (1) the assessment category of test equipment; (2) the category of response questionnaire; and (3) the category of technical test assessment. The analysis technique uses Instrument Test and Statistical Test, where the assessment instrument has been validated first.

The development of e-modules in this study was validated by four validators: two material experts and two media experts. The instruments used in this study include: (1) E-Module Validation Sheet: Used by material experts and media experts to assess the feasibility of e-modules based on aspects of content, design, interactivity, and usability. (2) User Response Questionnaire: Measures student satisfaction with display aspects, ease of use, and learning effectiveness. (3) Pre-Test and Post-Test: Used to measure the improvement of students' understanding of the material before and after using the e-module.

Data Analysis

Data Analysis Techniques use data obtained by the following techniques: (1) Validation Analysis: Data from expert validation sheets are analyzed using validation and practicality percentages, with validation categories from invalid to very valid, (2) Student Response Analysis: Questionnaire results are analyzed with descriptive statistics to see the level of student acceptance of e-modules, (3) Learning Outcome Improvement Analysis: Pre-test and post-test data are analyzed using t-test and N-gain test to determine the improvement of student understanding after using the e-module. With this approach, the research is expected to produce a Flipbook-based e-module that is valid, practical, and effective in Basic Electrical learning. The validity data analysis is calculated using the following equation:

$$\% = \frac{Skor\ Item\ Yang\ diperoleh}{Maksimum\ Skor\ Yang\ diperolah}\ x\ 100 \qquad (1)$$

The following table shows the validity categories of learning tools based on the final score obtained on a scale (0-100).

Table 1. Categories of Learning Media Validity

Category	Interval (%)
Highly Valid	81 – 100
Valid	60 – 80
Quite Valid	41 – 59
Less Valid	21 – 40
Cancel	0 – 20

The calculation of student response data analysis to interactive e-modules uses the following equations:

$$\% = \frac{skor\ item\ yang\ diperoleh}{skor\ maksimum}\ x\ 100 \qquad (2)$$

The respondents' response criteria can be categorized as in Table 2:

Table 2. Response Questionnaire Criteria

Category	**Interval (%)**
Excellent	81 – 100
Good	60 – 80
Pretty good	41 – 59
Not Good	21 – 40
Very Not Good	0 – 20

The calculation of the improvement analysis uses the following t-test formula:

$$t = \frac{M - \mu}{S_x} \qquad (3)$$

Average sample (M) minus population means you are comparing your sample to (μ), divided by the tandard error (Sx). A quantitative analysis called the regular acquisition test is needed to determine the importance of

improving student learning outcomes. The regular reinforcement test is carried out using the normal reinforcement formula, namely:

$$N_{gain} = \frac{nilai\ postest - nilai\ pretest}{nilai\ maksimum - nilai\ pretest} \quad (4)$$

With the following acquisition categorizations:

Table 3. Categories of Value Ngain

Category	Value
High	$N_{aain} \geq 0.7$
Keep	$0.3 \leq N_{aain} < 0.7$
Low	$N_{aain} < 0.3$

FINDINGS

Products developed in research that have been conducted, digital learning media that are interactive, interesting, and easily accessible. Innovative digital learning media in the form of e-module development using flipbook applications. The researcher developed the e-module using a flipbook application that can be accessed through a Google Drive link on a mobile phone or personal computer, and using an internet connection. The results of the development of flipbook-based interactive e-modules are as follows:

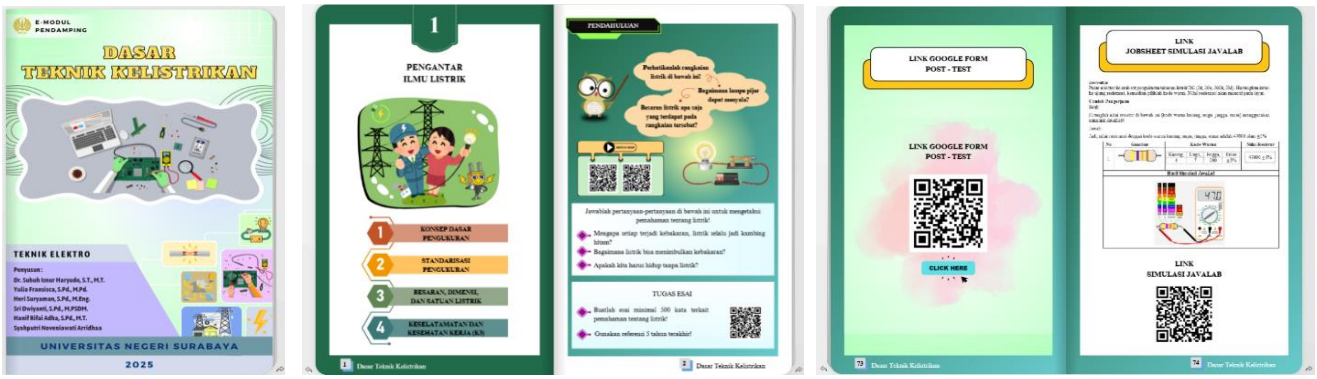

Figure 2. Sample of E-Module Development Results

The design of the e-module structure includes learning objectives, subject matter, illustrations, learning videos, practice questions, and series simulations. This module is designed as a means of learning in digital form that can be accessed and learned sequentially and systematically in 5 activities, namely: (a) Introduction to Electrical Science, (b) Law of Electricity, (c) Concept and Application of Electric Current, (d) Concept and Application of Electric Voltage, (e) Measurement of Electrical Power and Energy. Flipbooks were chosen as a presentation medium because they present modules with a print book-like appearance but with digital features such as quick navigation, attractive visual displays, and the insertion of interactive elements. Some special materials, such as pre-test and post-test questions, videos, and simulation designs, are presented in barcodes. The design also considers active learning and visual learning approaches to improve students' absorption of Basic Electrical materials.

The development of the e-module has been evaluated at each stage to be improved based on input from validators and respondents. Improvements were made to the feasibility of e-modules related to the validity, practicality, and effectiveness of learning media. The results of the analysis and evaluation of validity, practicality, and effectiveness are as follows:

Validity of e-Modules

The development of this Flipbook-based interactive e-module was validated by four experts who understand media and materials. Validation is carried out to ensure validity and practicality as an interactive learning medium. The results of the media validation that have been carried out can be seen in Figure 3:

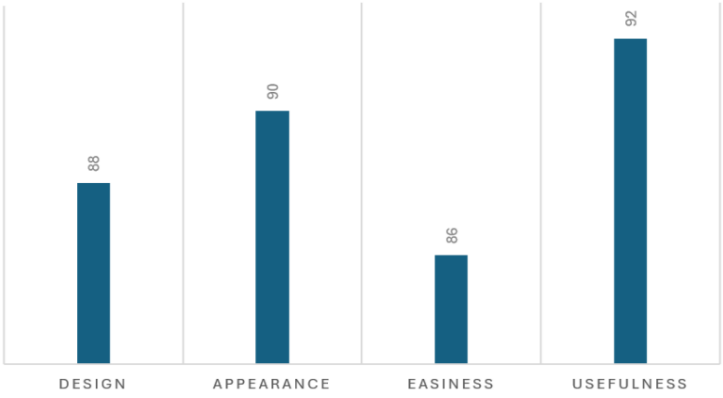

Figure 3. Graph of media validation results

Media validation consists of 4 (four) assessment aspects: design, appearance, convenience, and utility. Based on the analysis data, the results of the media validation showed the following: (1) the design aspect showed 88%, (2) the display aspect had a score of 90%, (3) the convenience aspect had a score of 86%, and (4) the usability aspect had a score of 92%—the average score of the four aspects obtained of 89% which can be categorized as very valid.

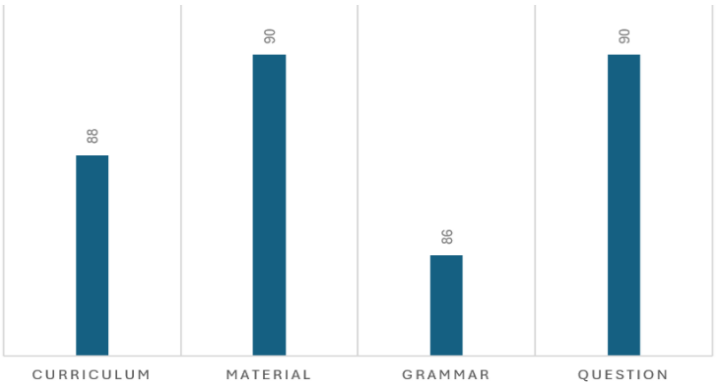

Figure 4. Graph of material validation results

Furthermore, material validation consists of 4 (six) aspects of assessment, namely: curriculum, materials, grammar, and questions. Figure 3 shows a graph of the results of the material validation. The average score of the material validation results from 4 aspects obtained 88.5% which can be categorized as very valid. By looking at the material and media validation results, it shows that this e-module obtained an average score of 88.7%, which is in the category of very valid and practical, so that it can be used in learning.

Students' Responses to the E-Module

Student response analysis data results were obtained through a response questionnaire instrument. Students filled out the response questionnaire after conducting a trial on learning media. The response questionnaire in the experiment was limited to measurements of appearance, use, and effectiveness. Small-scale e-module testing was carried out to obtain supporting data as material for practical evaluation. The results of the response analysis test are shown in Figure 5.

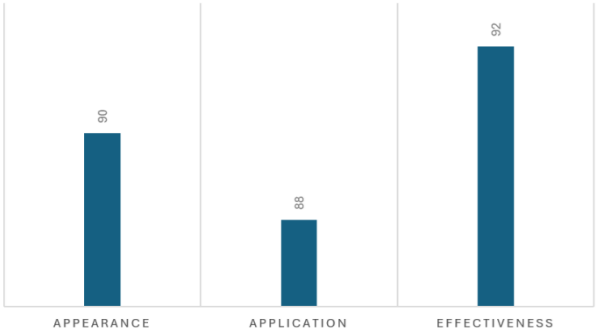

Figure 5. Graph of student response results

The results of the analysis data showed 90% of the display aspect, 88% of the Ease of Use aspect, and 92% of the effectiveness, with an average of 90% categorized as Excellent. This analysis showed that the students' responses gave positive assessments, showing that the Flipbook-based Basic Electrical e-module was well received and considered helpful in the learning process.

Improved Learning Outcomes

Pre-tests and post-tests were carried out to measure the effectiveness of e-modules in improving students' understanding of basic electrical materials. The average pre-test and post-test results are shown in Table 4.

Table 4. Test resultsof the pre-test and post-test scores

Group	Pre-Test Scores	Post-test Scores
Example	80	80
Lowest Score	40	62
Highest Score	82	96
Average	55.5	82.6
Standard Deviation	12.76	7.95

The results of the paired sample t-test in Table 4 showed a difference in learning outcomes with an average pre-test score of 55.5 and an average post-test score of 82.6, with a standard deviation of 12.76 and 7.95. The results of this study prove that the innovative flipbook e-module developed can improve critical thinking skills and problem-solving in learning. This increase shows increased understanding across students' abilities, with low and high initial understanding—N-gain test results, as shown in Table 5. The analysis of the N-gain test showed an average of 0.57, which is in the moderate category. These results show a significant increase in conceptual understanding, but it has not been maximized.

Table 5. N-gain Score Test Results

	N	Minimum	Maximum	Mean	Standard Deviation
N-gain_score	80	0.39	0.85	0.5737	0.10832
N_gain_Persen	80	39	85	57.37	10.832
Applicable (N) (in the direction of the list)	80				

DISCUSSION

The development of flipbook-based interactive modules in learning basic electrical concepts has positively improved students' conceptual understanding. The development of this e-module is specifically to help lecturers and first-level students in the learning process. The learning stages in this e-module are based

on case studies and adjusted to the needs of students, namely to support the understanding of basic electrical concepts. Flipbooks as a presentation medium provide visual advantages and accessibility, which can increase students' motivation and understanding. These findings support research on digital-based interactive media, which significantly increase learning effectiveness, especially in complex and technical engineering materials (Mahmudah et al., 2022; Öberg et al., 2024).

The content feasibility aspect focuses on the material in the e-module regarding up-to-dateness, scope, and accuracy. The pedagogical aspect in this e-module focuses on the completeness of the material that refers to the case study approach to problem solving, so that it can improve students' understanding of the concept of Basic Electricity. The PUEBI language guides the language feasibility aspect, using communicative and interactive language in the learning process. The development of e-modules by paying attention to the constituent parts in accordance with the indicators of the validation instrument can produce a valid e-module (Ismaniati & Iskhamdhanah, 2023).

The validation results show that this flipbook-based e-module meets content, design, and interactivity quality standards. Based on validator input, minor revisions have been made to the navigation structure and the addition of interactive elements. Improvements are made to help users understand the material more easily, interestingly, and interactively. The electronic modules developed should contain interactive features such as animations, videos, quizzes, and flipbook navigation, providing a more dynamic learning experience than conventional media (Yani et al., 2020; Wati & Syafriani, 2023). The design also considers active learning and visual learning approaches to improve students' absorption of the material (Sriyanti et al., 2021). Improvements and additions of interesting features to e-module learning media can increase motivation and understanding of basic electrical science concepts. The visualizations presented in this flipbook module, such as electric current flow animations, simulations of relationships between variables (voltage, current, and resistance), and interactive question practice features, help students understand concepts more concretely and in-depth. After the evaluation, all aspects of validation, both media and materials, are stated in valid criteria to test the product on students. The e-module test was carried out to obtain data as material for practical evaluation.

The results of the limited trial of the e-module during several meetings showed that students were more enthusiastic and active in participating in learning. This increased motivation can be attributed to the media's ability to present interactive visualizations**,** which makes it easier for students to understand abstract concepts such as electric current and voltage. They can access the material independently and repeat parts they do not yet understand. This kind of visualization plays a role in building a better mental representation. Synchronous merging of text and images can improve conceptual comprehension by supporting two cognitive processing channels (verbal and visual). E-modules help deliver abstract material, making it more concrete and easier to understand (Joglekar et al., 2022). Students are invited to understand the concept of Basic Electricity with interactive features, such as quizzes, exercises, and simulations, to improve critical thinking skills and analyze problems about Basic Electricity (Hidayati et al., 2024). Interactive exercises or reflective questions in the flipbook encourage students to think, not just passively read. Features such as flexible navigation, engaging visuals, and interactive practice questions also increase students' engagement *(*Commitment*)* in the learning process (Wu et al., 2025).

The response from students was also very positive, with the majority stating that this medium helped them learn independently and have fun. Students' self-study controls when using flipbooks, allowing them to learn according to their rhythm and learning style. Using flipbooks as a format to present e-modules has been proven to increase students' accessibility and reading interest**,** as it resembles print modules but with more attractive digital features. This positive response is data to support the validation results carried out as evaluation material. The results of this study show that e-modules are valid and practical to be used in the learning process. This aligns with research conducted by Evenddy et al. (2021) regarding the development of flipbooks as a digital learning medium, which is very valid and practical to be used in the learning process. In addition, developing e-modules can enrich and expand students' learning experiences through approaches that are contextual and relevant to their lives.

Evaluation is carried out through two stages: formative (during the development process) and summative (after implementation). The results of the summative evaluation showed a significant increase in student understanding, as evidenced by the pre-test and post-test results, which increased by an average of 48.83%. A significant improvement in learning outcomes shows that this e-module is effective in helping students understand the concept of Basic Electricity. This aligns with research by Ermiyati et al. (2024), which states that e-Modules are considered valid, practical, and effective if they can improve student learning outcomes while encouraging creativity and independence in learning. Digital-based interactive media significantly increase learning effectiveness, especially in complex and technical engineering materials (Suherman, 2025). However, despite the improvement, the N-gain value 0.57 has not yet reached the high category. This shows that flipbook media, although effective, have not been able to fully answer the challenges in learning basic electrical concepts. Some of the factors that cause this can come from: (1) Students' digital literacy readiness, where not all students are used to learning independently through interactive media, (2) Complexity of materials, such as the application of electrical laws or the concept of mixed circuits that still require verbal explanation from the teacher, (3) Technical factors, such as device limitations and connections that are not optimal. The development of digital learning media requires a more integrated and flexible approach that considers the complex interactions between technology, pedagogy, and students' abilities (Milkova & Moldoveanu, 2025).

The development of flipbook-based e-modules as an innovative learning medium can be feasible for the learning process. However, it needs to be further tested on a larger scale and for longer. This module is not a substitute for learning, but rather a tool that enriches the learning experience and allows students to repeat the material independently at their own pace. These results imply the importance of the continuous development of flipbook modules to be more adaptive to students' learning styles. In addition, these results show that flipbooks can be an alternative solution in the digital learning era. However, their implementation must be supported by educational infrastructure policies and a flexible curriculum to apply these learning innovations evenly.

CONCLUSION

Developing an interactive e-module based on a flipbook significantly improves the conceptual understanding of electrical basics. The e-modules developed can be said to be valid, practical, and effective in supporting the learning process. Integrating digital technology through interactive Flipbook media makes it easier to deliver material and increases students' motivation and interest in learning, improving the quality of learning. This shows that e-modules are suitable as an innovative alternative learning medium in the digital era.

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