

Development of E-module Internet of Things (IoT) Antares by PT. Telkom Indonesia Based on Science, Technology, Engineering, and Mathematics (STEM) for Vocational High School Students

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Abstract: This research is motivated by a needs analysis among teachers and students at SMK Negeri 4 Bandung. From the distribution of a needs analysis questionnaire in the class XII TOI-1, it was found that 85% of students expressed a strong need for a STEM-based IoT e-module, with a high level of agreement on its development. Similarly, it was revealed that teachers also strongly require a STEM-based IoT e-module, with 95% agreeing on its necessity. To develop the STEM-based IoT E-module, Flip Pdf Professional application was utilized. The aim of this research and development was to describe the process of developing the E-module and to understand the responses of teachers and students to the e-module. The research method employed was R&D (Research and Development) using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The result of this research was the successful development of a STEM-based IoT e-module through the ADDIE development model. The feedback from teachers reached 95.63%, falling into the "Very Good" category, and the feedback from students was 81.38%, also considered "Very Good." It was concluded that the use of the e-module facilitated easier understanding of the material and made the learning activities more engaging.

Keywords: e-module, STEM, ADDIE, Internet of Things

INTRODUCTION

The current rapid advancement in science and technology necessitates that learners, as vital national resources, must possess comprehensive knowledge, proficient skills, and effective methods and ways of learning (Firdaus & Hunaepi, 2016). The educational process critically requires the evolution of scientific knowledge and technology to enhance the teaching and learning experience (Sriwahyuni et al., 2019). Technological advancements, especially in the field of the Internet of Things (IoT), have brought about significant changes across various life sectors, including industry, agriculture, healthcare, and others. IoT, a concept that connects diverse devices and physical objects through the internet, enables more efficient data exchange and control (Junaidi, 2015). Vocational High Schools (SMKs) play a crucial role in preparing young generations to face the challenges of this advanced technological era. SMKs' curricula are oriented towards practical and technical skills, requiring students to be well-prepared to meet the sophisticated demands of the industrial world (Marlina & Jayanti, 2019).

Electronic modules, commonly referred to as e-modules, represent an evolution from traditional printed modules, systematically organized and presented in an electronic format accessible online for independent use by students (Tia, 2020). E-modules, as technological teaching materials, align with 21st-century learning principles, which include the integration of technology (Refitaniza & Effendi, 2022). Aminingsih & Izzati (2020) notes that this century's skills demand

human resources proficient in science, technology, engineering design, and mathematics, hence the expectation for educators to amalgamate these four disciplines. An appropriate approach to meet these 21st-century skill demands is the Science, Technology, Engineering, and Mathematics (STEM)-based approach.

Utilizing STEM as a 21st-century learning method represents an innovation that can enhance educational quality and prepare globally competitive generations. Integrating STEM into Indonesian education can develop students' creative, innovative, and critical thinking skills, enabling them to make decisions and solve everyday problems, as well as effectively communicate and collaborate, skills crucial for 21st-century life (Izzati et al., 2019).

This study aligns with Laili's (2019) research, which found that using e-modules in the learning process assists students in faster material comprehension and encourages teacher-student interaction. The relevance of this current research lies in developing an e-module and utilizing the STEM method. The distinction lies in the choice of the module being developed. A previous study by Novianto et al. (2018) on "Project-Based Learning Physics Module Development on Static Fluid Material to Enhance Class X High School Students' Creativity" demonstrated that learning with STEM-based modules effectively enhances students' creativity. Thus, it is anticipated that the development of this e-module will positively impact student learning.

Based on the needs analysis of students and teachers, with 95% of teachers strongly agreeing, it is clear that teachers greatly support the development of a STEM-based e-module to teach IoT introduction to students. Teachers believe that an e-module incorporating instructional videos, real-life examples, and everyday IoT applications will enhance students' understanding and interest, while the analysis revealed that 85% of students see a strong need for a STEM-based e-module on IoT introduction. The expectation is that the e-module will increase students' enthusiasm and active participation in the learning process, potentially enhancing their learning outcomes and making it easier for them to understand the material.

Therefore, this research will focus on developing the STEM-based IoT Antares E-module designed to teach students the basic concepts of IoT. The development of this e-module is expected to simplify material comprehension for students and create an engaging educational resource. The study aims to understand the development process of the IoT Antares STEM-based e-module for vocational high school students and to gauge the reactions of both teachers and students to this development.

METHOD

This section elaborates in detail how the research is conducted to address each research objective. The main components of this section include (use relevant ones) the location of the research, data used, research design or plan, research targets, data collection techniques, instrument development, data analysis, and testing the accuracy of the results.

According to Sugiyono (2019), the Research and Development (R&D) method is used to develop and test the effectiveness of a product. For the development of the e-module learning media in this research, the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) approach is employed (Sugiyono, 2019). ADDIE is one of the systematic approaches in designing and developing text, audiovisual materials, and computer-based materials in learning. This instructional design model has been widely used in educational methodology. The model involves five stages: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation. These stages are visually represented in Figure 1.

Detailed Process Development of e-Module Using the ADDIE Model

This section describes the sequential stages of e-module development using the ADDIE model for this research:

1. Analysis Stage:

- The analysis stage involves field information gathering, where observations and needs analyses are conducted as a foundation for e-module development. This stage

also justifies the need for an e-module. Following observations, relevant information is collected from trustworthy sources, followed by an analysis of issues related to the development of learning media for vocational high school students.

2. Design Stage:

- The subsequent step is the design stage, where a prototype or design of the e-module is created based on the identified needs. This stage consists of two sub-stages:
 - Interface Design: Detailing the specifications of the application to be developed. The interface is organized using diagrams and storyboards.
 - Storyboard Design: Offering a more detailed approach than the interface design, as it visually represents the components within the block diagrams. The interface design from the previous stage guides the e-module design, with the storyboard providing a visual representation.

3. Development Stage:

- This stage involves integrating content such as images, videos, or simulations to create the e-module learning media. Activities include gathering module display references, content materials, supportive videos, creating attractive backgrounds, and finding relevant animations. Revisions are made based on feedback from Antares PT. Telkom Indonesia and supervising lecturers.

4. Implementation Stage:

- The evaluated and revised e-module undergoes a limited trial to gauge the responses of teachers and students. A pilot test is conducted with 1 teacher and 32 students from a class XII Programmable Control System (TOI). After using the e-module, students and teachers complete a questionnaire to provide feedback.

5. Evaluation Stage:

- The research involves two types of assessments. Formative assessment occurs at every research stage, incorporating reviews, inputs, and discussions with supervising lecturers. Summative assessment takes place at the end to evaluate user responses and the developed product based on the analysis of data from user feedback questionnaires. The results are then detailed.

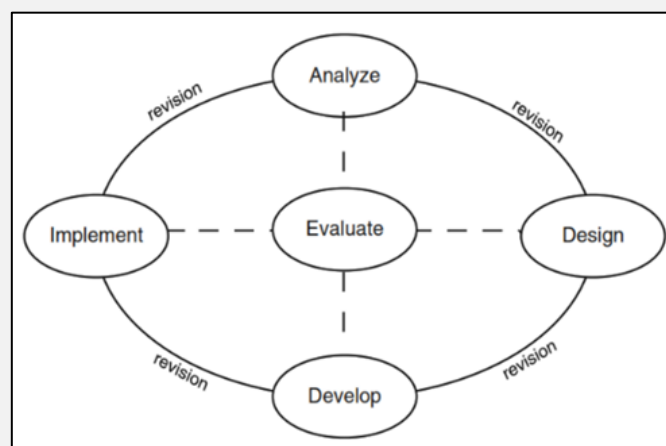


Figure 1. Development Procedure of Research Using the ADDIE Model (Branch, 2009)

The subjects involved in this study are teachers of the Programmable Control System subject

and students of class XII in the Industrial Automation Engineering (TOI) department at SMK Negeri 4 Bandung. The choice of this school is based on practical considerations for conducting trials in this environment. The focus of the research object is on the IoT Antares E-module.

Each instrument is constructed using a Likert scale ranging from very positive to very negative, expressed as: Strongly Agree (ST) with a score of 4, Agree (S) with a score of 3, Disagree (TS) with a score of 2, and Strongly Disagree (STS) with a score of 1. The obtained data are then converted into percentages using the formula (Arikunto, 2010).

$$P = \frac{\text{Total score obtained}}{\text{Total maximum score}} * 100\% \quad (1)$$

After calculating the percentages, the evaluation criteria for the development of the E-module can be determined based on Table 1.

Table 1. Evaluation Criteria

No	Criteria	Percentage
1	Very Good	$76\% \leq x \leq 100\%$
2	Good	$51\% \leq x \leq 75\%$
3	Fair	$26\% \leq x \leq 50\%$
4	Poor	$0\% \leq x \leq 25\%$

Adaptation: Nengsih (2021)

This table is used to interpret the results obtained from the percentage calculation of the responses to the E-module. Each range of percentages corresponds to a specific criterion that qualitatively describes the level of success or effectiveness of the E-module based on the feedback or scores given by the users (teachers and students in this case).

- Very Good ($76\% \leq x \leq 100\%$): Indicates that the E-module is highly effective or has been very well received by the users.
- Good ($51\% \leq x \leq 75\%$): Suggests that the E-module is effective or well received, but there may be some areas for improvement.
- Fair ($26\% \leq x \leq 50\%$): Implies that the E-module has a moderate level of effectiveness or acceptance. This range signals a need for significant improvements.
- Poor ($0\% \leq x \leq 25\%$): Indicates that the E-module is not effective or has not been well received. This category signifies that major revisions and restructuring may be necessary.

RESULTS & DISCUSSION

The analysis results indicate a 95% approval rating with the criterion of "Strongly Agree," showing that the XII TOI 1 Programmable Control System teachers strongly support the development of the STEM-based e-module. Similarly, the student analysis for class XII TOI 1 reveals a need for the STEM-based IoT e-module, with an 86% rating falling under "Strongly Agree." The e-module, incorporating instructional videos, real-life examples, and daily IoT applications, is expected to enhance students' understanding and interest. Teachers anticipate that the e-module will be complemented with easy-to-understand language, images, graphs, as well as tasks and exercises to test student comprehension. Interactive features are hoped to encourage active student participation in learning, facilitate discussion, and improve students' independent learning skills. Additionally, teachers wish for the e-module to be easily accessible on mobile devices, enabling convenient student usage.

In the design phase, two steps are involved: interface design and storyboard development. The specifications of the e-module under development are detailed comprehensively. This stage will outline the method of creating the e-module interface through block diagram representations. Block diagrams provide a simplified visual representation of the learning media's sequential flow,

while storyboards serve as visual details that depict the e-module's appearance before entering the design development phase.

The development phase includes activities to combine content materials such as images, videos, and simulations into the e-module learning resource using Figma design software, Microsoft Word, and Flip PDF Professional. The design is created using Figma software, compiled into PDF format using Microsoft Word, and packaged into an e-module using Flip PDF Professional. This packaging process also integrates instructional videos, interactive quizzes, and simulations. The pages resulting from the development are as follows:

- Intro Page: The opening or cover page includes the e-module title, illustrative images, and a start button to begin using the e-module, depicted in Figure 2a.
- Main or Home Page: Contains various menu options, including usage instructions, developer profile, introduction, material choices, and student worksheet options, depicted in Figure 2b.
- Instruction Page: Provides guidance on using the e-module with brief explanations, back to the main menu button, and next/previous buttons, depicted in Figure 2c.
- Video Learning Page: Contains instructional videos that students can play and enlarge, depicted in Figure 2d.
- Content Page: Includes material in each chapter of the e-module with navigation buttons for each chapter, along with back to the main menu and next/previous buttons, depicted in Figure 2e.
- Student Worksheet Page: Consists of interactive individual and group tasks and exercises, depicted in Figure 2f.
- Exercise Page: Accessible from the student worksheet page for individual tasks that students can complete directly, with immediate results available, depicted in Figure 2g.

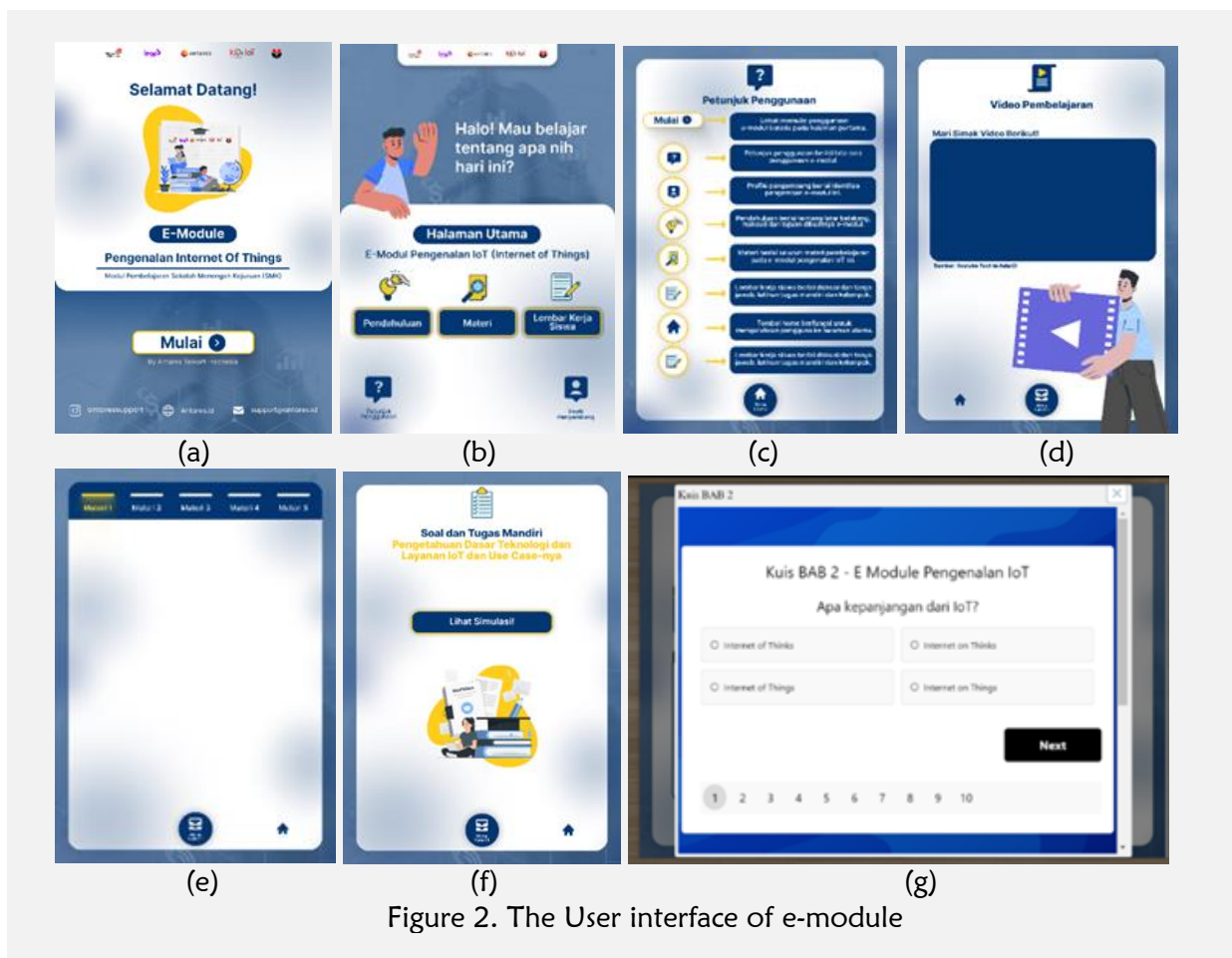


Figure 2. The User interface of e-module

In the development phase of this research, once the e-module product is completed, it undergoes a thorough review before moving to the implementation phase. This review is conducted by representatives from Antares PT. Telkom Indonesia and the supervising lecturers during guidance sessions. Their objective is to evaluate and provide feedback on the e-module under development, ensuring that any necessary improvements are identified, and revisions are made before proceeding to the implementation phase. The outcomes of these revisions, based on the suggestions and inputs received, are reflected in the following updates (as illustrated in [Figure 3](#)):

1. Font Change ([Figure 3a](#)): The font type was modified to enhance readability. This adjustment ensures that the text in the e-module is user-friendly and accessible for all students.
2. Removal of Redundant Buttons ([Figure 3b](#)): Unnecessary buttons, such as 'next' and 'previous', which were already available in the Flip PDF feature set, were removed. This change simplifies the user interface, making the e-module more streamlined and easier to navigate.
3. Change from "Chapter" to "Material" ([Figure 3c](#)): The term 'Chapter' was changed to 'Material' to better reflect the content structure. This terminology adjustment aligns the e-module with educational practices and makes it more intuitive for the users.
4. Addition of Simulations for Group Tasks ([Figure 3d](#)): Simulations were added to enrich the group tasks section. These interactive elements are intended to enhance the learning experience by providing practical, hands-on applications of the theoretical concepts taught in the e-module.

These revisions are aimed at improving the overall effectiveness, usability, and educational value of the e-module, ensuring that it meets the needs of both teachers and students and aligns with the current technological and pedagogical standards.

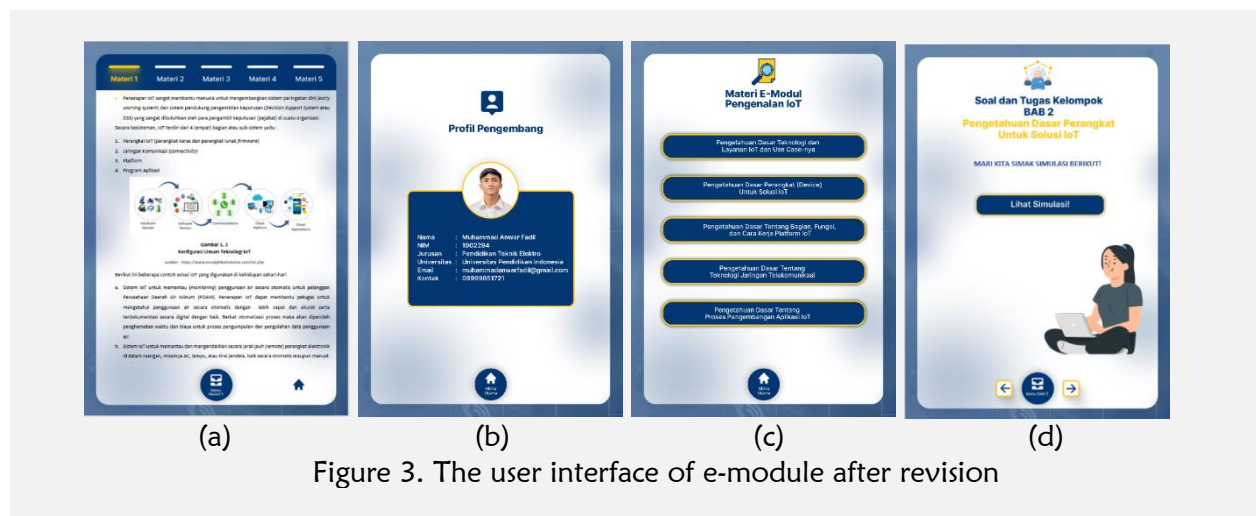


Figure 3. The user interface of e-module after revision

In the implementation phase of the e-module, which has completed the development process, a limited trial is conducted to gather feedback from teachers and students regarding the developed e-module. The trial involved a teacher responsible for the Programmable Control System and 32 students of class XII TOI 1 at SMK Negeri 4 Bandung. The following table presents the summary of the teachers' responses as seen in [Table 2](#).

The results indicate an overwhelmingly positive response to the e-module, with all aspects rating as 'Very Good.' The aspects evaluated include the STEM-based e-module design, content components, presentation quality, linguistic clarity, and graphical elements. The high percentage scores reflect the e-module's effectiveness and its successful integration of the necessary educational components. The average score of 95.63% under the 'Very Good' category demonstrates the e-

module's overall excellence in meeting the educational needs and expectations of the teachers at SMK Negeri 4 Bandung.

Table 2. Recapitulation of Teacher Response Questionnaire

Aspect	Number of Items	Score	Maximum Score	Percentage	Criteria
STEM-Based E-module Aspect	8	31	32	96.88%	Very Good
Content Component Aspect	2	7	8	87.50%	Very Good
Presentation Aspect	2	8	8	100.00%	Very Good
Linguistic Aspect	4	15	16	93.75%	Very Good
Graphical Aspect	9	36	36	100.00%	Very Good
Average				95.63%	Very Good

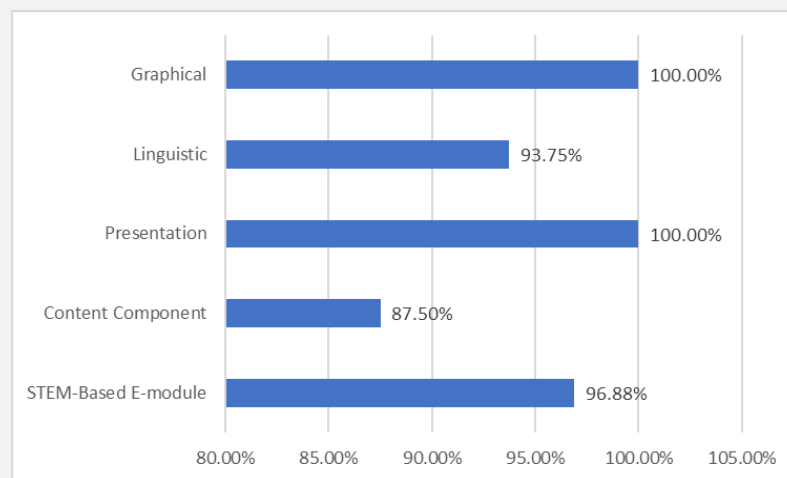


Figure 4. Recapitulation of Teacher Response Questionnaire

Based on the summary of teacher responses from the questionnaire, it is observed that the components of the STEM-based e-module received the following percentages: 96.88% for the STEM-based e-module aspect, 87.50% for content validity, 100% for presentation, 93.75% for linguistic aspects, and 100% for graphical aspects. Overall, all aspects received an average percentage of 95.63%, which falls within the "Very Good" criterion.

Table 3. Recapitulation of Student Response Questionnaire

Aspect	Number of Items	Score	Maximum Score	Percentage	Criteria
STEM-Based E-module Aspect	8	840	1024	82,03%	Very Good
Content Component Aspect	2	200	256	78,13%	Very Good
Presentation Aspect	2	215	256	83,98%	Very Good
Linguistic Aspect	4	419	512	82%	Very Good
Graphical Aspect	9	932	1152	80,90%	Very Good
Average				81.38%	Very Good

The summary of student responses from the questionnaire indicates that the STEM-based e-module aspect received a percentage of 82.03%, content validity was 78.13%, presentation was 83.98%, linguistic aspects were 82%, and graphical aspects were 80.90%. On the whole, all aspects received an average percentage of 81.38%, which is categorized as "Very Good".

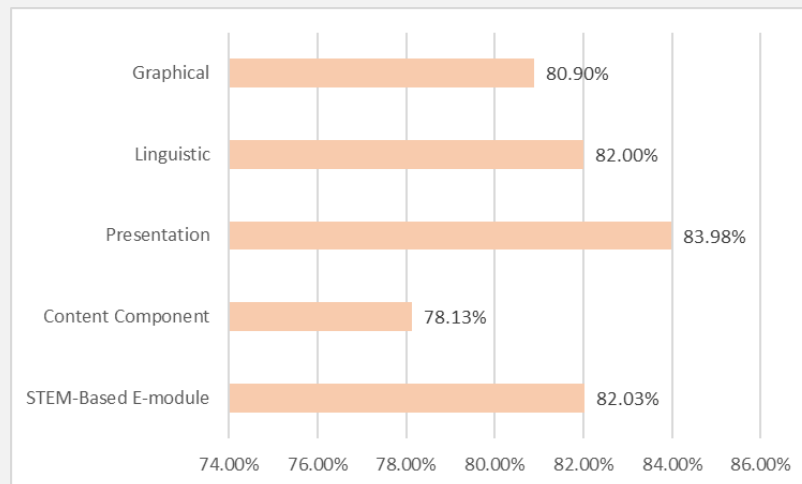


Figure 5. Recapitulation of Student Response Questionnaire

The feedback collected through questionnaires from both teachers and students on the STEM-based e-module provides insightful data that is crucial for evaluating the effectiveness of this educational tool. The results from teachers are particularly encouraging, showcasing an overwhelmingly positive reception, with average ratings bordering on excellence at 95.63%. Each component assessed—ranging from the e-module's adherence to STEM principles, its content, presentation, language use, to graphical design—was rated "Very Good," with two aspects, presentation and graphical design, achieving perfect scores. This indicates that the e-module is not only meeting the educational objectives set forth by the instructors but also excelling in engaging them through high-quality material presentation and visual appeal.

On the other hand, the student feedback, while slightly lower, still falls into the "Very Good" category with an average of 81.38%, signifying a strong acceptance and recognition of the e-module's value in their learning process. Students rated the e-module highly across various aspects, though they noted slightly lower scores in content validity and graphical aspects compared to other categories. This disparity in scoring between teachers and students—particularly in content validity—may reflect different expectations or experiences with the e-module and suggests areas where further refinement could be beneficial.

Both perspectives highlight the e-module's success in integrating STEM into the learning experience, suggesting that such resources are well-positioned to enhance educational engagement and comprehension. The strong ratings for presentation and linguistic aspects from both groups indicate that the e-module is both user-friendly and effectively communicates complex concepts, which are critical factors for learning tools in technical subjects such as IoT.

Moreover, the high scores in graphical aspects from teachers, and to a lesser extent from students, emphasize the importance of visual design in digital learning environments. As graphical elements can greatly influence a student's engagement and ability to understand information, the slightly lower score from students may be an area to explore for improvement.

In conclusion, the favorable responses from both teachers and students affirm the e-module's potential as a robust teaching aid. The overall satisfaction with the e-module's STEM-based approach reinforces the value of such educational innovations in meeting the needs of 21st-century learners. However, the slight divergence in teacher and student perceptions offers a valuable opportunity for developers to fine-tune the e-module, ensuring it resonates with and is fully optimized for its target audience.

CONCLUSION

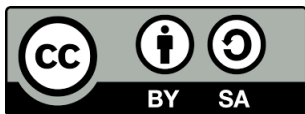
The development of the e-module based on the ADDIE model has been successfully completed through five stages: firstly, the Analysis phase, where the need for the e-module was identified; secondly, the Design phase, which involved planning the product development; thirdly, the Development phase, where the design was created using the Figma application, content material was incorporated using Microsoft Word, and video content, as well as worksheets, were compiled using Flip PDF Professional; fourthly, the Implementation phase involved a limited trial with students to gather teacher feedback; and fifthly, the Evaluation phase.

The feedback from the Programmable Control System teachers at SMK Negeri 4 Bandung regarding the STEM-based IoT e-module was overwhelmingly positive, with a 95.63% approval rating, classified under the "Very Good" criterion. Similarly, student responses from the Industrial Automation Engineering department at SMK Negeri 4 Bandung yielded an 81.38% approval rating, also falling under the "Very Good" criterion. These results lead to the conclusion that the use of the e-module can facilitate a better understanding of the material and make learning activities more engaging.

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