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Development of Interactive Flipbook-Based E-Module for Teaching Algorithms and Basic Programming in Higher Education

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This article contributes to:

ABSTRACT

The COVID-19 pandemic has forced educational institutions to switch to online learning, which has posed challenges related to the lack of interactive digital teaching materials. Specifically, the available materials in the Algorithm and Basic Programming course are static and text-based, making it difficult for students to study independently. This study aims to develop an interactive digital book-based e-module with multimedia features to enhance student engagement and understanding and evaluate the quality and effectiveness of the e-module. The study used the 4D (define, design, development, disseminate) development model. The define stage involved a needs analysis, while the design stage included media selection, video preparation, and quiz development. The development stage consisted of validation by three expert validators and limited trials with 30 students. Data analysis used descriptive methods by calculating the validation percentage and trial results. The validation results showed an eligibility of 89.00% for media and 88.33% for content, both in the "excellent" category. The limited trial received positive responses, averaging 81.00%, indicating that the e-module is easy to use and can increase learning motivation. This e-module is highly suitable for online learning in the Algorithm and Basic Programming course. Further research is recommended to test the effectiveness of this e-module on a larger scale and evaluate its long-term impact on student learning outcomes.

Keywords: E-Module; Flipbook; 4D; Educational Technology; Distance Learning

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1. INTRODUCTION

The Coronavirus Disease 2019 (COVID-19) pandemic has had significant impacts across various sectors, including not only health, social, and economic domains, but also the education sector [1]. The adverse effects of the pandemic have been particularly felt within the realm of education. Policies regarding learning during the pandemic were formalized through the Joint Ministerial Decree (Surat Keputusan Bersama, SKB) of Four Ministers, which provided guidelines for educational implementation for the 2020/2021 academic year amidst the COVID-19 crisis [2]. One of the stipulations of this policy required that higher education institutions shift the mode of instruction for both theoretical and practical courses from in-person meetings to distance learning (Pembelajaran Jarak Jauh, PJJ) [3]. PJJ, also referred to as distance learning or online learning (daring), enables interaction between educators and students who are not physically present in the same location [4].

The challenges associated with online learning are quite varied, ranging from unequal access to educational facilities across different levels of education, especially in terms of technology, internet connectivity, and even electricity availability. Additionally, students in both schools and universities often struggle to obtain adequate resources to support online learning, such as computers, smartphones, and internet data packages [5]. Beyond infrastructural issues, online learning can lead to student passivity and feelings of being overwhelmed, exacerbated by the monotony due to a lack of innovative online learning media, the stress from an overload of online assignments, and difficulties in understanding course materials while studying independently at home [6], [7].

Despite these challenges, the acceleration of technological and digital transformation remains a crucial factor to ensure the continuity of education. The shift to online learning during the COVID-19 pandemic has certainly presented challenges for educational institutions at all levels. Currently, higher education institutions are heavily reliant on technology and internet access to conduct distance learning. The advantages of online learning include supporting physical distancing measures and offering greater flexibility in terms of time and location, as it can be conducted asynchronously, allowing learning to take place anytime and anywhere [8].

The Informatics Engineering Education Study Program at the Faculty of Engineering, Universitas Negeri Padang, particularly faculty members teaching courses such as algorithms and basic programming, continue to optimize the use of the university's e-learning platform to conduct online classes for both theoretical and practical subjects. Interactions between lecturers and students are conducted virtually, utilizing video teleconferencing applications and various other online learning platforms. Additionally, some lecturers have implemented blended learning methods. Blended learning combines online instruction via e-learning with in-person classroom sessions, all while adhering to health protocols [9].

However, fully online learning remains the preferred approach since it eliminates physical contact between lecturers and students, significantly reducing the risk of COVID-19 transmission [10]. To ensure the quality of online learning, the use of e-learning platforms needs to be supported by comprehensive digital learning resources, such as e-books, e-modules, and other similar materials [11].

Before the pandemic, lecturers—particularly those teaching courses such as algorithms and basic programming—primarily relied on printed modules and textbooks for in-person instruction. However, during the pandemic, lecturers faced significant challenges in providing learning resources via e-learning platforms, as suitable digital teaching materials were not yet available. As a result, the teaching materials for algorithms and basic programming courses remained largely in print format, which was insufficient to meet the needs of both lecturers and students in an online learning environment. This situation highlights a critical gap, considering that learning resources are essential for effective education [12].

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The availability of appropriate teaching materials not only aids lecturers in designing effective instructional plans but also helps students master the learning competencies required [13]. In response to these challenges, lecturers are increasingly expected to innovate, particularly in developing digital-based instructional materials to adapt to the demands of online learning. According to research conducted by Maynastiti et al. [14], the development of learning materials is essential to create a learning experience that is not only more engaging but also more effective and efficient. Their findings demonstrated that the development of digital learning resources, such as e-books, can make a positive contribution to the learning process, particularly in the context of chemistry education for high school students [15].

Similarly, research by Hofer et al. [16] indicated that the use of well-designed learning materials significantly aids teachers in delivering course content. Learning resources are structured in a systematic sequence to foster an environment conducive to student learning. One innovative approach to digital resources is the use of flipbook-based digital textbooks. This type of media is creative, innovative, and informative, incorporating text, images, audio, video, and animations, thereby making the learning process more accessible and engaging. A flipbook is essentially a PDF document that has been transformed into a digital book with the interactive feel of a printed book, featuring pages that "flip" like a physical book. These digital books are portable and can be easily accessed on various devices, including computers, laptops, tablets, and Android smartphones [17].

The advantages of the developed e-module application based on an interactive digital book include: (1) the presence of a flipbook effect that mimics the experience of flipping through the pages of a physical book; (2) integration of images, reference links, audio, instructional videos, quizzes, and exercises; (3) the resulting product is easily accessible via computers and smartphones and can be published on websites.

Given the background, literature review, and research concept, there is a clear need to focus on developing digital teaching materials, especially for courses such as algorithms and basic programming. This research aims to design an interactive digital book-based e-module application with several key features: being paperless, supporting self-instructional learning, consolidating all content into a comprehensive package (self-contained), functioning independently (stand-alone), adapting to different learning contexts (adaptive), and being both user-friendly and easy to understand.

2. METHODS

This study adopts a research and development (R&D) approach. R&D is a research method used to investigate, develop, and test the effectiveness of a particular product. The development model employed in this study is the 4D model, also known as the Four-D model [18].

The 4D model consists of four main stages: define, design, development, and disseminate. The define stage focuses on identifying the specific needs, challenges, and objectives of the learning content, which includes analyzing the target audience, setting learning goals, and outlining the necessary competencies that students need to achieve. The design stage involves planning the structure of the product, including the layout of instructional materials, the selection of digital tools, and the organization of the content for the interactive e-module. In the development stage, the actual creation of the e-module takes place, integrating multimedia elements such as videos, quizzes, and animations. This phase also includes testing the initial version for usability and effectiveness. Finally, the disseminate stage is concerned with distributing the finished e-module to the target audience, implementing it in real educational settings, gathering feedback, and making any necessary adjustments for broader adoption. This entire process is focused on developing an interactive digital e-module that supports online learning, particularly for subjects like algorithms and basic programming, with the goal of producing an engaging

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and effective learning resource. The stages are visually summarized in Figure 1, which provides an overview of how the 4D model is applied in developing this digital learning tool.

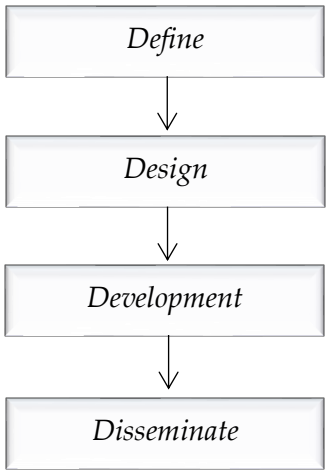

Figure 1. 4D development model

The define phase focuses on defining and analyzing the needs for developing the e-module. This stage begins by identifying the problems faced, such as the lack of digital learning resources that align with pandemic conditions to support online learning via e-learning platforms. Key activities in this phase include designing the cover and template layout for the e-module, analyzing the user characteristics, and selecting the specific course content to be developed—in this case, the subject of algorithms and basic programming. Additionally, this phase involves defining the learning objectives and determining the relevant materials to be included in the e-module.

The design phase, as illustrated in Figure 2, focuses on planning how to present and organize the content. This includes selecting the format for text-based content, choosing suitable media types such as audio or instructional videos, and creating quiz questions and practice exercises for the e-module. The outcome of this phase is a preliminary product, resulting in an initial design of the e-module application.

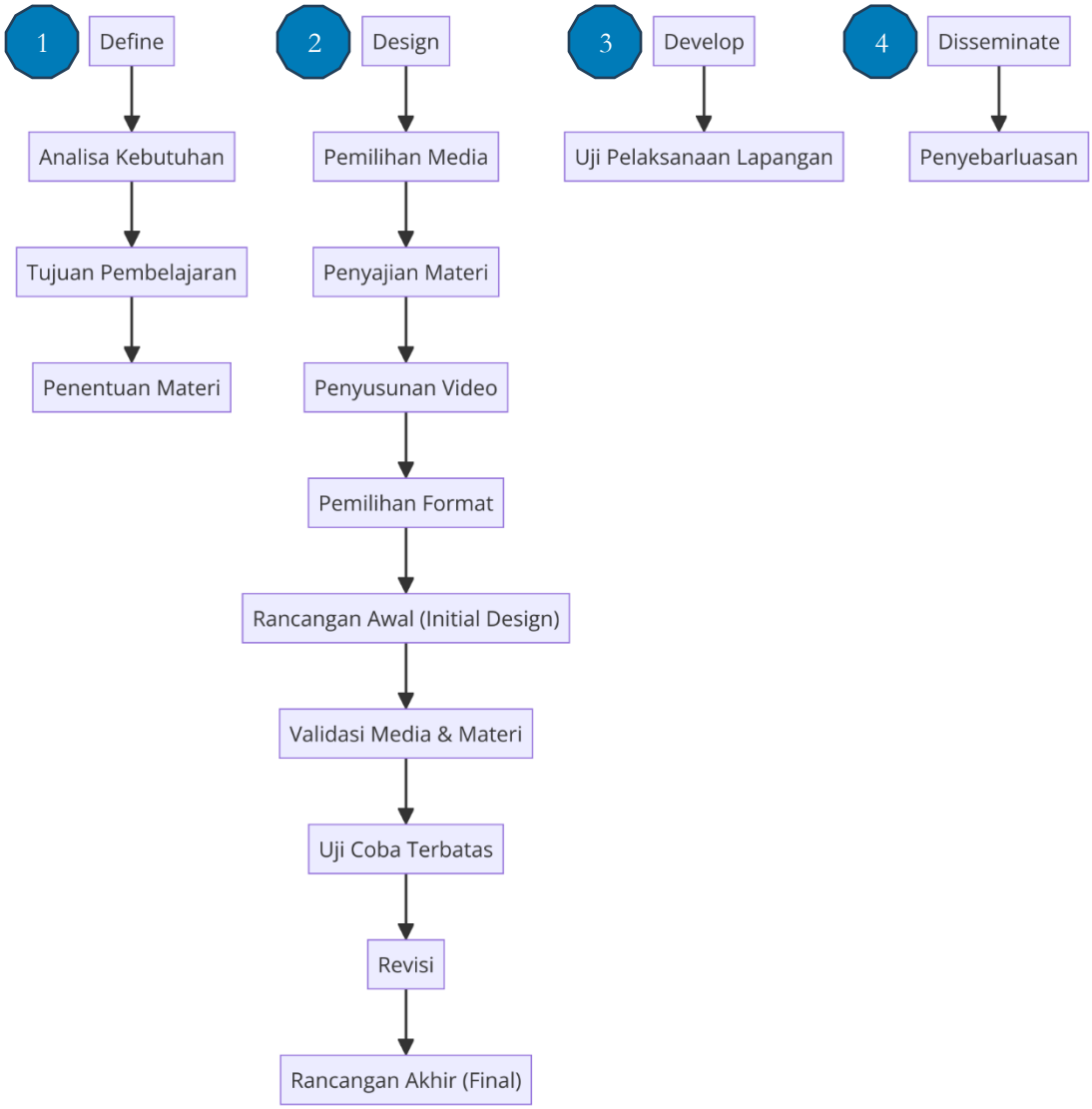

Figure 2. Development procedure

In the subsequent develop phase, a validation test was conducted to assess the feasibility of the e-module. During this stage, the e-module underwent evaluation by three expert validators specializing in instructional material development, particularly in e-modules. The validation instrument consisted of media validation and content validation components. A Likert-scale questionnaire was employed as the validation instrument to measure various assessment aspects related to both media and content, as detailed in Table 1 and Table 2.

Table 1. Media and content validation aspects

No.	Media Aspect	No.	Content Aspect
1	Design	1	Systematic Structure
2	Interactivity	2	Content Presentation
3	User Guide	3	Video Presentation
4	Consistency	4	Readability
5	Navigation	5	Evaluation

Table 2. Likert scale

Scale	Description
5	Very Good
4	Good
3	Fair
2	Poor
1	Very Poor

The data analysis in this study employed both quantitative and qualitative approaches. Quantitative analysis involved calculating the percentage of validity, while qualitative descriptive analysis was used to interpret the data obtained, enabling more meaningful conclusions to be drawn. The formula for calculating the validity percentage is as follows:

$$v = \frac{\sum x\ validator}{\sum x\ max} \times 100\% \quad (1)$$

Description:

v	validity percentage
∑x validator	total score given by the validators
∑x max	maximum possible score

Kriteria kelayakan e-modul diperoleh dengan analisis persentase sesuai Table 3 berikut ini:

Table 3. E-Module validation criteria

Percentage (%)	Criteria
81 – 100	Highly Feasible
61 – 80	Feasible
41 – 60	Fairly Feasible
21 – 40	Less Feasible
0 – 20	Not Feasible

A small-scale trial of the e-module was conducted after validation to obtain data for evaluation purposes. The research subjects for the limited trial (small-scale testing) were undergraduate students in the Informatics Engineering Education program at Universitas Negeri Padang, who were enrolled in the Algorithms and Basic Programming course. The number of participants in the limited trial was 30 students. This trial was carried out to assess the ease of use and readability of the e-module, which could then serve as data for product improvement evaluation. The data from the limited trial were collected using a response questionnaire filled out by the students after using the developed e-module. The formula and assessment criteria (Table 4) for the limited trial to evaluate the ease of use and readability of the e-module are as follows:

$$uji = \frac{\sum R}{N} \times 100\% \quad (2)$$

Description:

uji	score from the limited trial
∑R	total score from responses
N	maximum possible response score

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Table 4. Criteria for limited trial assessment

Percentage (%)	Criteria
81 – 100	Excellent
61 – 80	Good
41 – 60	Adequate
21 – 40	Poor
0 – 20	Very Poor

This research focuses only on the development of the e-module, covering the stages from definition, design, and development, including validation and limited trials. The assessment of the e-module's effectiveness will be conducted after the evaluation of the small-scale or limited trials, followed by the final stage, which is dissemination. The dissemination process will involve providing training, distributing the application, along with user guides for the e-module, so that it can be utilized by a wider audience.

3. RESULTS

3.1 *Define*

The initial stage aims to gather data on needs analysis for the development of the e-module application. This needs analysis includes aspects such as student characteristics, problem analysis during e-learning, and field observations. The results of this process revealed that there were no suitable teaching materials aligned with online learning via e-learning platforms, as the existing resources were still in the form of printed materials. Additionally, it was found that 86.78% of students enrolled in the Algorithms and Basic Programming course reported that the teaching materials provided by lecturers on e-learning platforms were difficult to understand when studying independently at home and were less engaging as they were solely text-based. Based on these findings, it was determined that the development of the e-module would focus on the Algorithms and Basic Programming course, comprising a total of 12 chapters. The details of the content are provided in Table 5.

Table 5. Content of the E-module

No.	Content
1	Programming Algorithms
2	Basic C++ Programming
3	Variables & Input/Output
4	Fundamental Data Types
5	Operators
6	Flow Control: Selection
7	Flow Control: Looping
8	Flow Control: Jump Statements
9	Arrays
10	Pointers & Dynamic Memory
11	Functions
12	User-Defined Data Types

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The development of this e-module required several software tools, including Photoshop, Microsoft Word, Nitro PDF, and Flip PDF Professional. Photoshop was used for designing the cover and page templates of the e-module. Microsoft Word was utilized for organizing the content, while Nitro PDF was employed to convert Word documents into PDF (Portable Document Format) files. Flip PDF Professional was used to package all the content files, integrating features such as flipping pages, audio, video, links, images, quizzes, and exercises into a cohesive e-module application. The use of appropriate educational media, especially multimedia content like video, audio, and visual aids, has been proven to effectively enhance learners' abilities, particularly in content that demonstrates movement [17]–[18].

Figure 3 shows the cover design of the e-module. The font used is Libre Baskerville, combined with a blue background with the color code #39a1ff. The e-module design is packaged attractively, as appealing educational media can stimulate students' interest, motivation, and engagement in learning.

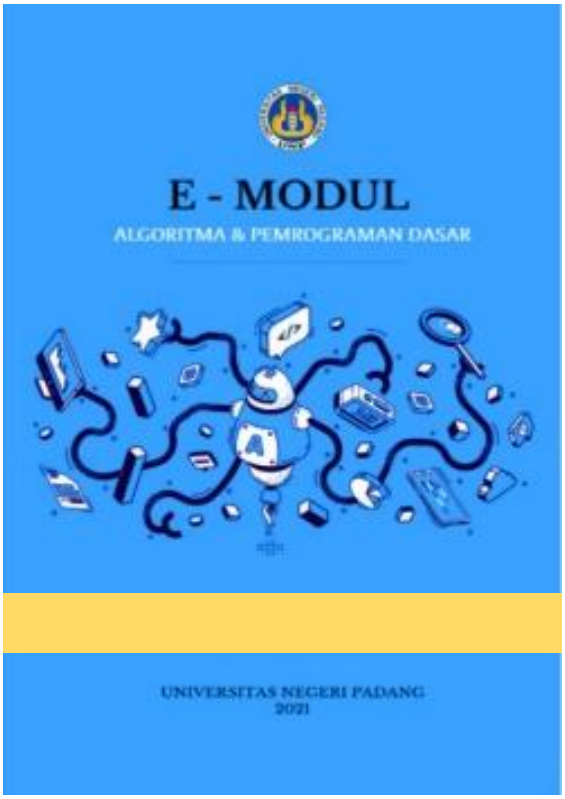

Figure 3. E-module cover display

3.2 *Design*

In the design stage, the presentation of content, navigation buttons, videos, and the creation of quizzes and exercises were organized. The overall design concept of the e-module is illustrated in Figure 4.

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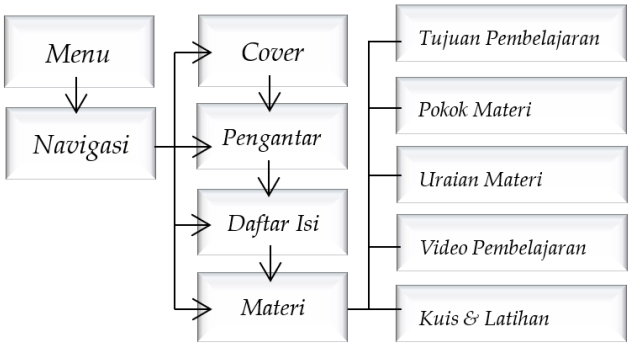

Figure 4. Design concept

The e-module consists of a cover page, preface, table of contents, and content modules. The interface of the e-module upon launching can be seen in Figures 5-6.

Figure 5. Loading screen

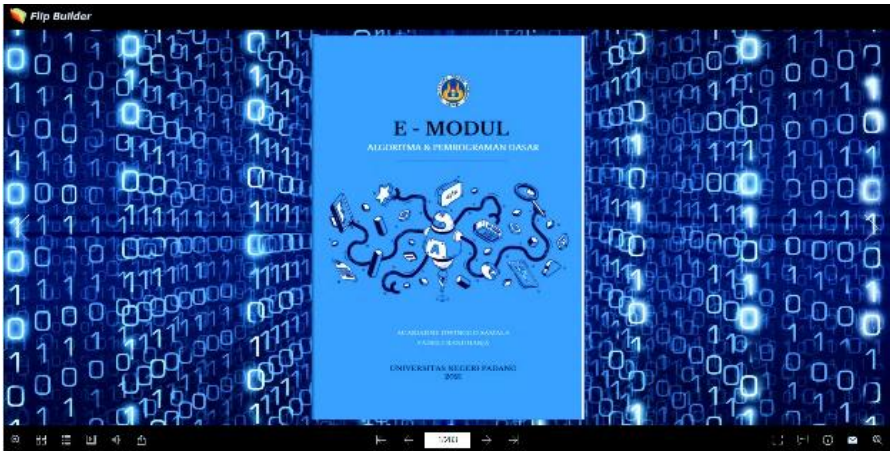

Figure 6. Main interface

The main menu includes three sections of navigation buttons. First, in the center of the application window, there are navigation buttons: First, Previous, Page Number, Last, and Next. Second, in the bottom-left corner of the window, there are buttons for Zoom In, Thumbnails, Table of Contents, Auto Flip, Sound, and Social Share. Third, in the bottom-right corner, there are buttons for Fullscreen, Switch Language, About, Share, and Magnifying Glass. The functions of these navigation buttons are detailed in Table 6.

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Table 6. Navigation buttons in the e-module

No.	Button	Function: Displays
1	First	First page
2	Previous	Previous page
3	Page Number	Current page number
4	Last	Last page
5	Next	Next page
6	Zoom In	Zoom in
7	Thumbnails	Page shortcuts
8	Table of Contents	Table of contents
9	Auto Flip	Automatic page flip
10	Sound	Toggle sound (on or off)
11	Social Share	Share the application
12	Fullscreen	Fullscreen mode
13	Switch Language	Change language
14	About	Information about the e-module
15	Share	Contact
16	Magnifying Glass	Magnifier

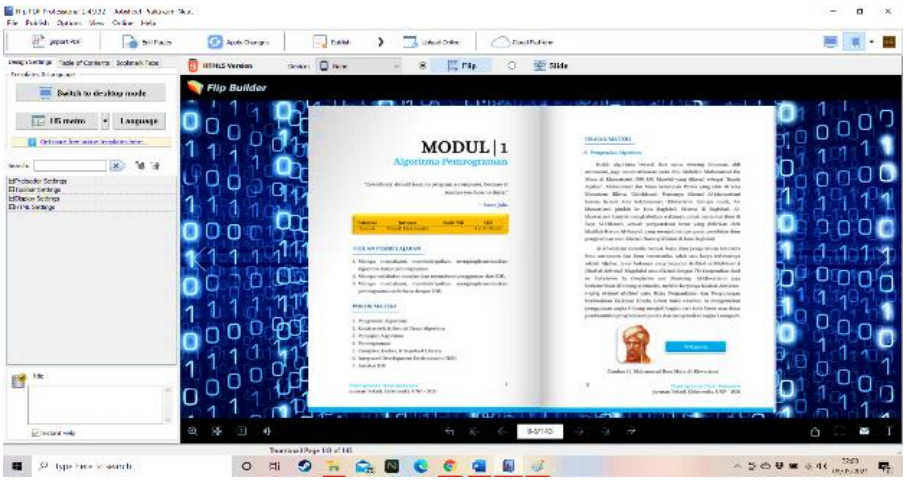

Figure 7. Content presentation

In the content presentation, images and link buttons are included to display reference pages as supplementary reading materials, enriching students' understanding of the subject matter. There are three types of buttons on the content presentation page, distinguished by their colors: blue, yellow, and red. The blue button directs users to a reading page linked to a URL that serves as an additional reading reference, the yellow button links to quiz questions consisting of multiple-choice questions, and the red button plays instructional videos within the e-module, as illustrated in Figures 7–11.

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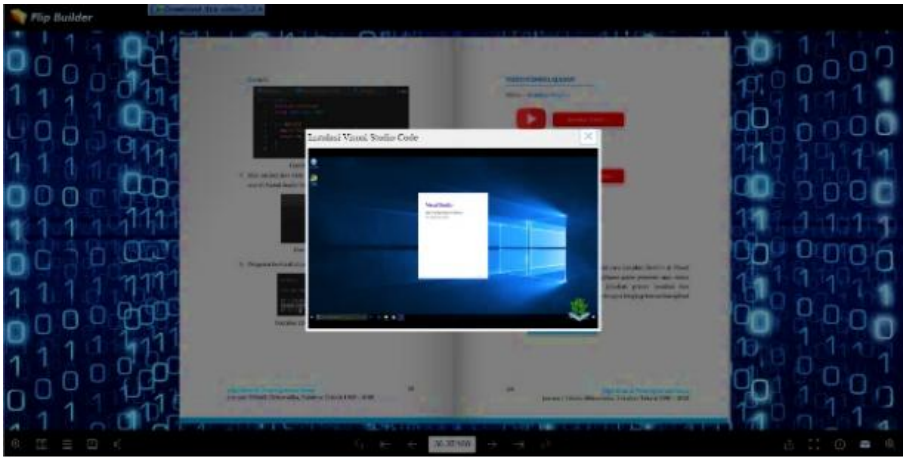

Figure 8. Video presentation

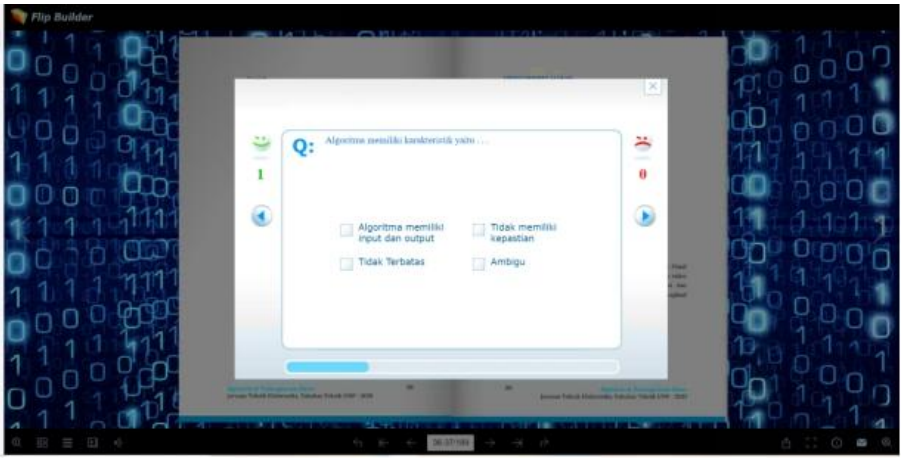

Figure 9. Quiz presentation

Figure 10. Magnifying glass

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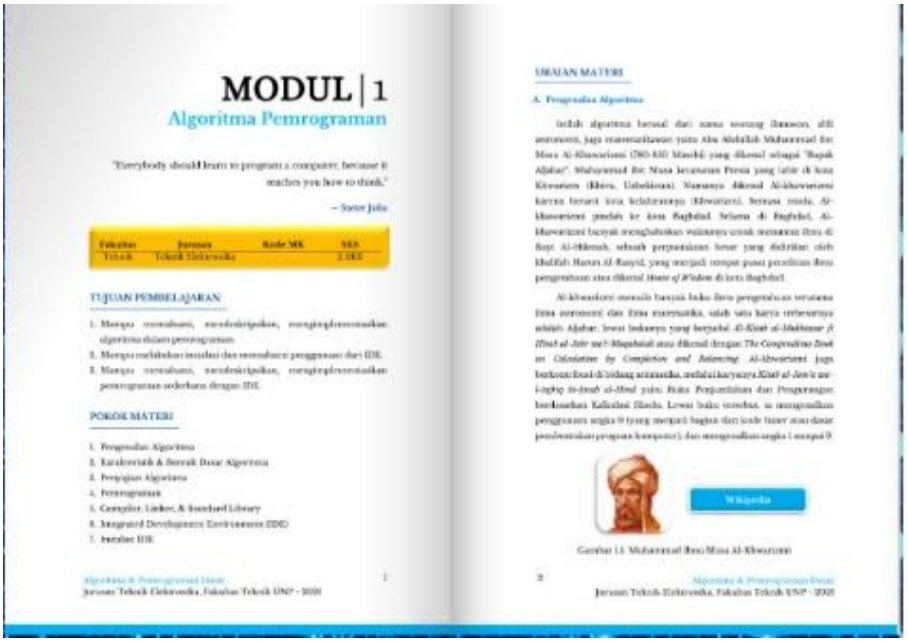

Figure 11. Module content display

3.3 *Development*

At this stage, the e-module was validated by three experts in the field of educational media. This step was conducted to ensure that the developed e-module possesses the characteristics of a good learning module and aligns with user needs. Media validation consisted of five assessment aspects: design, interactivity, user guide, consistency, and navigation. The validation questionnaire included 20 statements, rated on a Likert scale of 1 to 5, resulting in a maximum possible score of 100.

Based on Table 7, the media validation results showed that the first validator (V1) scored 89, the second validator (V2) scored 91, and the third validator (V3) scored 87. Thus, the overall average score across all aspects from all validators was 89.00. In percentage terms, the media validation result was 89.00%, which falls into the "Highly Feasible" category. Content validation also involved five assessment aspects: systematic structure, content presentation, video presentation, relevance, and evaluation. The content validation questionnaire also contained 20 statements, rated on a Likert scale of 1 to 5.

Table 7. Media validation results

Aspect	V1	V2	V3	Avg
Design	18	20	18	18.67
Interactivity	17	18	17	17.33
User Guide	18	18	17	17.67
Consistency	17	18	17	17.33
Navigation	19	17	18	18.00
Total	89	91	87	89.00

Based on Table 8, the content validation results indicated that the first validator (V1) scored 90, the second validator (V2) scored 88, and the third validator (V3) scored 87. The overall average score across all aspects

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from all validators was 88.33. In percentage terms, the content validation result was 88.33%, which also falls into the "Highly Feasible" category.

Table 8. Content validation results

Aspect	V1	V2	V3	Avg
Systematic Structure	15	17	16	16.00
Content Presentation	18	17	17	17.33
Video Presentation	19	17	18	18.00
Relevance	19	18	18	18.33
Evaluation	19	19	18	18.67
Total	90	88	87	88.33

3.4 *Disseminate*

In this study, all validation aspects, both media and content, were categorized as "Highly Feasible," indicating that the product could proceed to small-scale testing with students. In the small-scale or limited trial, the e-module application was used by students, who then provided feedback by filling out a response questionnaire. The response questionnaire in the limited trial was restricted to measuring the appropriateness of the user guide, ease of use, and readability of the content presentation in the e-module. Below are the results of the limited trial conducted with 30 students enrolled in the Algorithms and Basic Programming course, based on 15 statements in the response questionnaire.

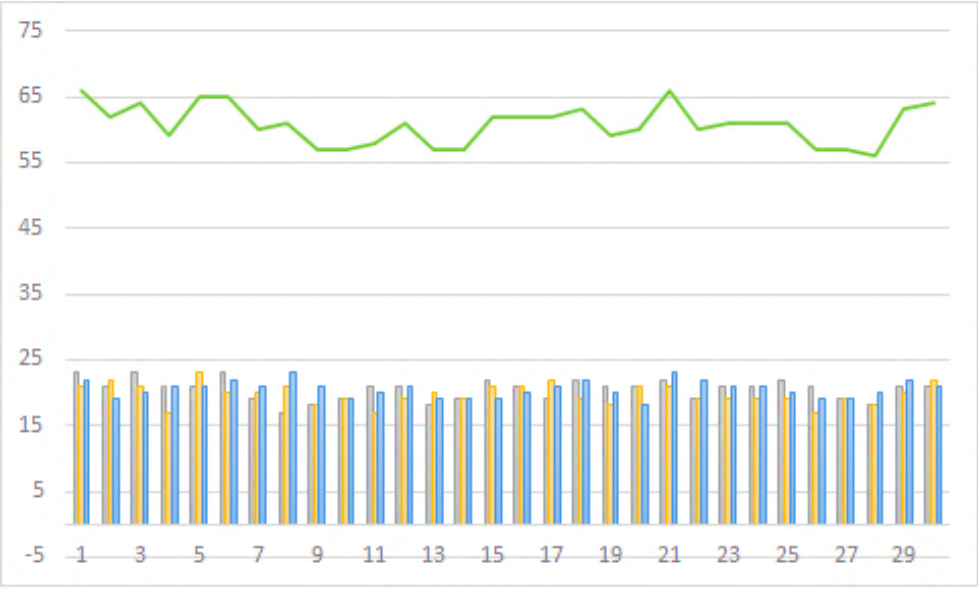

Figure 12. Limited trial score results

Based on the limited trial data, the average total score from all students was 60.76 (Figure 12). The maximum score for the response questionnaire was 75. Thus, the percentage for the limited trial in terms of the appropriateness of the user guide, ease of use, and readability of the e-module content was calculated as follows:

$trial = (60.76/75) \times 100\%$
$trial = (0.81) \times 100\%$
$trial = 81.00\%$

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The percentage obtained from the limited trial with 30 students was 81.00%. This indicates that the user guide appropriateness, ease of use, and content readability of the e-module are categorized as "Very Good." Based on these results, no revision is required, and the product

4. DISCUSSION

This study focused on developing an e-module based on an interactive digital book designed to support student self-learning, particularly in the Algorithms and Basic Programming course. The research findings show that the developed e-module achieved excellent validity based on evaluations by three expert validators and a limited trial with students. Media validation achieved a feasibility percentage of 89.00%, while content validation scored 88.33%, both of which fall into the "Highly Feasible" category.

The main advantage of this e-module is its integration with multimedia features such as videos, audio, images, and interactive quizzes. This aligns with findings from previous studies, which indicate that the use of interactive media can enhance student understanding and motivation [19]. This was confirmed by the limited trial results, which demonstrated that the e-module facilitated students' comprehension of previously challenging topics, especially given that previous teaching materials were static and text-based.

Compared to the printed teaching materials previously used, this e-module offers a richer and more diverse learning experience. The limited trial with 30 students in the Algorithms and Basic Programming course also indicated that the e-module's ease of use and readability were rated highly, with an average response score of 81.00%. This suggests that the product effectively addressed the readability and engagement issues identified during the needs analysis, where 86.78% of students found prior materials uninteresting and difficult to understand in an e-learning format.

This study also supports the findings of Suyasa et al. [20] and Syafruddin et al. [21], which emphasize the importance of developing digital teaching materials to improve the effectiveness of online learning. The use of an interactive digital book in the form of a flipbook that enables more interactive and dynamic learning has proven to positively contribute to students' learning experiences, as reported in previous studies.

However, this study is limited by the fact that testing was only conducted on a small scale. Although the validation and limited trial results were very positive, large-scale or field trials are necessary to confirm the effectiveness of this e-module in broader and more diverse settings. Further research is also needed to measure the impact of the e-module on students' learning outcomes in the long term, as well as its effectiveness in enhancing competencies in the Algorithms and Basic Programming course.

Overall, this study successfully developed an e-module that is feasible for use as a learning medium in distance education. This e-module is expected to serve as an effective solution to overcome the limitations of online learning and to support a more interactive and adaptive learning process in the future.

5. CONCLUSION

This study successfully developed an e-module based on an interactive digital book that can be used as a learning medium for the Algorithms and Basic Programming course. The e-module leverages multimedia features such as videos, audio, images, quizzes, and exercises, which have proven to be effective in enhancing student engagement, comprehension, and motivation in self-directed learning. The validation results demonstrated that the e-

module has excellent quality, with a media validation score of 89.00% and a content validation score of 88.33%, both falling into the "Highly Feasible" category.

The limited trial with 30 students also yielded positive feedback, with an average percentage score of 81.00%, indicating that the ease of use, readability, and attractiveness of the e-module were rated as "Very Good." Based on these results, it can be concluded that the e-module is suitable for use on a larger scale and has the potential to improve the quality of online learning.

The next step is to conduct large-scale testing to confirm the effectiveness of the e-module in broader learning scenarios and to measure its impact on students' learning outcomes in the long term. Additionally, the dissemination process is expected to promote the adoption of this e-module in other universities as an adaptive and interactive learning tool.

DECLARATIONS

Author's Contributions

Rama Putra Mahendri: Conceptualization, Methodology, Software, Inversitgation, Writing - Original Draft. **Mita Amanda:** Data curation, Writing - Review & Editing. **Ulfi Latifah:** Visualization, Investigation, Writing - Review & Editing. **Soha Rawas:** Supervision, Validation.All authors have read and approved the final version of this manuscript.

Competing Interests

The authors declare that there are no competing interests.

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