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DEVELOPMENT OF A MULTIMEDIA-BASED ELECTRONIC MAGAZINE ON BIOTECHNOLOGY MATERIALS FOR GRADE X SENIOR HIGH SCHOOL

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ABSTRACT

Rapid technological advancements require teachers and students to be able to utilize electronic learning media to clarify complex and abstract concepts. Biotechnology material for Grade X is considered interesting but relatively difficult to understand because it is multidisciplinary, abstract, and applicative in nature. Survey results indicate several problems, including students' difficulties in understanding modern biotechnology, difficulty in memorizing bacterial names in Latin, and limitations of practical activities in schools due to constraints in time, equipment, materials, and laboratory facilities. This study aims to develop a multimedia electronic magazine as a solution to facilitate understanding of biotechnology material and to provide virtual practical experiences. This study employed a Research and Development (R&D) method using the ADDIE model, conducted up to the development stage. Expert validation resulted in an average score of 3.55 (very valid), the first-stage trial involving university students obtained a score of 3.74 (very good), and the second-stage trial involving students obtained a score of 3.55 (very good). In conclusion, the developed multimedia electronic magazine is of very high quality with an average score of 3.62 and can be implemented in Grade X senior high school biotechnology learning.

Keywords: Multimedia Electronic Magazine; Biotechnology; Virtual Practicum; R&D.

INTRODUCTION

Rapid technological advancement has had a significant impact on various aspects of life, particularly education. Technological progress goes hand in hand with the development of science, requiring teachers and students to be able to utilize technology optimally. Teachers play an important role in providing visual experiences to clarify complex and abstract learning concepts so that they become more concrete and easier to understand through electronic learning media (Fakhriah, 2022). The demands of 21st-century learning also emphasize technological skills in addition to mastery of knowledge, where technology-based learning is considered more effective than classical teacher-centered approaches (Arifin & Mu'id, 2024).

The use of technology can improve the quality of education through the provision of relevant, engaging, and up-to-date learning media (Wibowo, 2023). Electronic learning media function as tools for delivering information that can be used both inside and outside the classroom with the help of electronic devices such as smartphones and computers (Tirsa, 2023). One form of electronic learning media is the electronic magazine (e-magazine).

An electronic magazine is an innovative learning medium in the form of a digital file that can be accessed through electronic devices (Rohmah et al., 2020). Electronic magazines contain various components such as a cover, user guide, table of contents, learning materials, and closing sections, presented in concise, clear, and communicative language (Muhammad, 2018). As a multimedia medium, electronic magazines can integrate text, images, audio, video, animation, and interactivity to enhance students' understanding.

Previous studies have shown that the use of electronic magazines can increase learning interest, conceptual understanding, and learning outcomes of students (Srikandi et al., 2020). This indicates the potential of electronic magazines as instructional materials, particularly in Biology learning.

In the Merdeka Curriculum, learning is adjusted to students' talents, interests, and learning environments, and provides flexibility for teachers to create high-quality learning experiences (Law Number 20 of 2003). One of the Biology topics for Grade X senior high school is Biotechnology, which is multidisciplinary, applicative, and relatively abstract in nature, thus requiring strong conceptual understanding.

Preliminary research conducted in several senior high schools in Pekanbaru showed that students experience difficulties in understanding modern biotechnology material, especially related to scientific terminology and abstract processes. In addition, limitations in time, laboratory facilities, and equipment and materials make biotechnology practical activities difficult to implement. The use of varied learning media is also still limited, and multimedia electronic magazines have never been developed. The learning process tends to be one-way, resulting in low student participation.

Based on these problems, it is necessary to develop learning media that can help students understand conventional and modern biotechnology materials and provide indirect practical experiences. Therefore, the researcher developed a multimedia electronic magazine equipped with animations and interactive links to make learning more engaging and easier to understand. This research is entitled "Development of a Multimedia Electronic Magazine on Biotechnology Materials for Grade X Senior High School."

RESEARCH METHODS

This study employed the Research and Development (R&D) method. Research and Development is a method used to produce a particular product and to test the effectiveness of that product. The development model used as the basis of this study was the ADDIE model, which consists of Analyze, Design, Development, Implementation, and Evaluation. However, in this study, the research was conducted only up to the Development stage.

Development Procedure

This research procedure employed the ADDIE model, consisting of the following stages: Analyze, Design, and Development. The stages carried out in this study were as follows:

Analyze Stage

The analysis stage aimed to determine and define the needs in the learning process and to collect various information related to the product to be developed, namely a multimedia electronic magazine as a learning medium. This stage was divided into several steps:

a) Curriculum Analysis
b) Learning Media Analysis

c) Material Analysis

Design Stage

After the analysis stage, the researcher designed the learning tools, the multimedia electronic magazine for Grade X senior high school biotechnology material, and the research instruments.

a. Design of Learning Tools
b. Design of the Multimedia Electronic Magazine
c. Design of Research Instruments

Development Stage

The development stage aimed to realize the product design that had been previously prepared. At this stage, the development of the learning objectives flow (ATP), Phase E teaching modules, and the multimedia electronic magazine on Grade X senior high school biotechnology material was conducted. The development process of the multimedia electronic magazine was as follows:

1) Designing the cover of the multimedia electronic magazine using attractive fonts, elements, and images through the Canva application. The cover contained several components, including the title, logo, topic/material, phase/grade, and supporting elements such as images relevant to the topic.
2) Designing and arranging the layout of the magazine content up to the back cover according to the previously designed multimedia electronic magazine plan.
3) After completing the design process of the cover and content layout using Canva, the multimedia electronic magazine file was downloaded in PDF format.
4) The downloaded PDF file was then uploaded to the Heyzine.com website to add a page-flipping animation.
5) After uploading to Heyzine.com, the researcher added videos, audio, and interactive links to make it more engaging and to provide a new learning experience for students.
6) After adding these supporting components, the multimedia electronic magazine was saved to ensure that the progress was not lost.
7) Once saved, the multimedia electronic magazine was ready to be used by downloading the QR code or copying the link to the multimedia electronic magazine.
8) The multimedia electronic magazine could be accessed via smartphones, laptops, computers, and tablets by visiting the link or scanning the downloaded QR code.

Data Collection Instruments

Research Instruments

The research instruments were tools used during data collection to obtain information useful for answering the research problems. The instruments used in this study were:

a) Validation Sheets
b) Respondent Questionnaires

Data Collection Techniques

Research data were obtained through the completion of validation sheets by validators and questionnaires filled out by respondents in limited trials Phase I and Phase II. The aspects assessed in the validation sheets included material aspects, language aspects, and graphical aspects. The validation sheets were completed using a rating scale and accompanied by critiques, arguments, and solutions related to the developed multimedia electronic magazine. The research data were obtained from the average validation results by validators, followed by limited trials Phase I and Phase II.

The limited trial Phase I was conducted with sixth-semester students of the Biology Education Study Program, Faculty of Teacher Training and Education, Universitas Riau, while the limited trial Phase II was conducted with students of MAN 3 Pekanbaru who had studied biotechnology material. The limited trials were conducted to determine the usability of the multimedia electronic magazine in terms of material aspects, attractiveness, and effectiveness. The limited trials were carried out by distributing the multimedia electronic magazine along with questionnaires to the selected students.

Data Analysis Techniques

After data collection, data analysis was conducted. The obtained data were analyzed using predetermined formulas to simplify and classify them into forms that were easy to read. Data analysis had two main objectives: to summarize and to describe the collected data.

Validation by Validators

The data analysis technique used in this study was descriptive analysis, aimed at describing the validation results by calculating the scores obtained from the validator assessment sheets to determine the validity of the developed multimedia electronic magazine. Validation was conducted using a Likert scale with scores ranging from 1 to 4. The data analysis stages were as follows:

1) Summing the scores for each indicator on the validity assessment sheet. The assessment categories used by validators followed the guidelines in Table 1.

Table 1. Categories of Validation Assessment

No.	Category	Score
1	Very Valid	4
2	Valid	3
3	Less Valid	2
4	Not Valid	1

(Source : Sugiyono, 2017)

2) Calculating the average score for each indicator using the following formula:

$$M = \frac{\sum fx}{N}$$

Where:
M = Average score
fx = Total score obtained
N = Number of validated components

3) The criteria for determining the validity category of the multimedia electronic magazine based on the average score of each indicator according to the Likert scale are presented in Table 2.

Table 2. Validity Criteria

No.	Average score	Category
1.	$3{,}25 \geq x \leq 4$	Very Valid
2.	$2.5 \leq x < 3.25$	Valid
3.	$1.75 \leq x \leq 2.5$	Less valid
4.	$1 \leq x < 1.75$	Not Valid

(Source : Sugiyono, 2017)

Limited Trials

After validation by validators, limited trials were conducted to evaluate the usability and feasibility of the developed multimedia electronic magazine on biotechnology material. Limited Trial Phase I involved 10 students from the Biology Education Study Program, Faculty of Teacher Training and Education, Universitas Riau. Limited Trial Phase II involved 32 Grade X students of MAN 3 Pekanbaru. The trial results were analyzed based on the developed assessment guidelines.

Table 3. Limited Trial Categories

No.	Assessment Score	Category
1.	4	Very Good
2.	3	Good
3.	2	Less Good
4.	1	Not Good

(Source: Sugiyono, 2017)

The results of the limited trials were calculated using the average score formula:

$$M = \frac{\sum fx}{N}$$

Where:
M = Average score
∑fx = Total score obtained
N = Number of limited trial components

The criteria for determining the limited trial results are shown in Table 4.

Table 4. Limited Trial Criteria

No.	Average score interval	Validity category
1.	3.25 ≤ x< 4	Very Good
2.	2.5 ≤ x < 3.25	Good
3.	1.75 ≤ x < 2.5	Less Good
4.	1≤ x < 1.75	Not Good

(Source : Sugiyono, 2017)

Quality of the Developed Multimedia Electronic Magazine

After validation and limited trials, the average score was calculated to determine the quality of the developed multimedia electronic magazine using the following formula:

$$M = \frac{X1 + X2 + X3}{3}$$

Where:
M = Average score
X_1 = Average validation score
X_2 = Average score of Limited Trial Phase I
X_3 = Average score of Limited Trial Phase II

Table 5. Quality Criteria of the Developed Electronic Magazine

No.	Average Score	Category
1.	3,25 ≥ x ≤ 4	Very Good
2.	2.5 ≤ x < 3.25	Good
3.	1.75 ≤ x ≤ 2.5	Less Good
4.	1 ≤ x < 1.75	Not Good

(Source : Sugiyono, 2017)

RESULTS AND DISCUSSION

Validation Results, Limited Trials, and Quality of the Multimedia Electronic Magazine on Biotechnology Material

The multimedia electronic magazine on Grade X senior high school biotechnology material was validated using validation sheets covering three aspects: material, language, and graphics. The material aspect consisted of six statement items, the language aspect consisted of three items, and the graphical aspect consisted of seven items. The average validation scores for each aspect are presented in Table 9.

Table 9. Average Validation Scores of the Three Assessment Aspects

No	Aspects of Multimedia Electronic Magazines	Average	Category
1.	Material aspect	3.74	SV
2.	Language aspect	3.35	SV
3.	Graphical aspect	3.57	SV
	Overall average	**3.55**	**SV**

Description: SV = Very Valid

Based on Table 9, the average score of the multimedia electronic magazine in terms of material, language, and graphics was 3.55, categorized as very valid. The highest score was obtained in the material aspect (3.74), while the lowest score was obtained in the language aspect (3.35), both categorized as very valid.

Results of Limited Trials Phase I and Phase II

After the multimedia electronic magazine was validated by validators, Limited Trial Phase I was conducted with 10 sixth-semester students of the Biology Education Program at Universitas Riau, followed by Limited Trial Phase II involving 33 Grade X students of MAN Pekanbaru who had studied

biotechnology material, using response questionnaires. Subsequently, Limited Trial Phase I and Phase II were carried out. The following section presents the results of Limited Trial Phase I and Phase II, along with the quality evaluation of the multimedia electronic magazine on biotechnology material.

Limited Trial Phase I (University Students)

Limited Trial Phase I with university students was conducted after the multimedia electronic magazine had been validated by validators and subsequently revised by the researcher. The average scores of Limited Trial Phase I for the multimedia electronic magazine in each aspect are presented in Table 10 below.

Table 10. Average results of Limited Trial Phase I (University Students) of the electronic magazine for each aspect

No.	Assessment Items	Average	Category
	Material Aspect		
1.	The biotechnology material presented in the multimedia electronic magazine helps students achieve learning objectives	3.75	SB
2.	The material and examples of biotechnology products presented in the multimedia electronic magazine are related to daily life	3.90	SB
3.	The images, videos, and audio presented in the multimedia electronic magazine are relevant to biotechnology material	3.90	SB
4.	The information presented in the multimedia electronic magazine is easy to understand	3.80	SB
	Average	**3.83**	**SB**
	Attractiveness Aspect		
5.	The overall design of the multimedia electronic magazine is attractive and not monotonous, increasing interest in learning biotechnology	3.60	SB
6.	The color composition used in the multimedia electronic magazine is appropriate, not overly bright, and does not disturb vision	3.75	SB
7.	The display of images, videos, and audio in the multimedia electronic magazine is clear and attractive	3.80	SB
8.	The multimedia electronic magazine provides new information/knowledge and a new learning experience, making learning more enjoyable	3.65	SB
	Average	**3.7**	**SB**
	Effectiveness Aspect		
9.	The multimedia electronic magazine on biotechnology material is arranged in a systematic and clear format	3.62	SB
10.	The instructions for using the multimedia electronic magazine are presented clearly and are not confusing for users	3.77	SB
11.	The language used in the multimedia electronic magazine is simple, clear, and easy to understand, enabling effective comprehension of biotechnology material	3.72	SB
12.	The type and size of the font used in the multimedia electronic magazine are appropriate and easy to read	3.55	SB
13.	The multimedia electronic magazine on biotechnology material can be used without special skills	3.82	SB
14.	The navigation buttons of the electronic magazine are easy to operate on various electronic devices	3.77	SB
	Average	**3.70**	**SB**
	Overall Average Score of All Aspects	**3.74**	**SB**

Based on Table 10, the results of Limited Trial Phase I involving university students obtained an overall average score of 3.74, indicating that the multimedia electronic magazine falls into the Very Good category. In the material aspect, the indicators with the highest scores were components 2 and 3, each with an average score of 3.90, categorized as Very Good. Meanwhile, the indicator with the lowest score in this aspect was component 1, with an average score of 3.75, which is still categorized as Very Good. In the attractiveness aspect, the indicator with the highest score was component 7, with an average score of 3.80, categorized as Very Good. The lowest score in this aspect was found in component 5, with an average score of 3.60, also categorized as Very Good.

In the effectiveness aspect, the indicator with the highest score was component 13, with an average score of 3.82, categorized as Very Good. The indicator with the lowest score was component 9, with an average score of 3.62, which is still categorized as Very Good. During Limited Trial Phase I of the multimedia electronic magazine, university students suggested replacing italic or cursive-style fonts with standard, clear, and easily readable fonts. They also recommended paying closer attention to writing format, such as correcting typographical errors and punctuation in the multimedia electronic magazine.

Limited Trial Phase II (Students)

Limited Trial Phase II with students was conducted after the multimedia electronic magazine had undergone Limited Trial Phase I with university students and was subsequently revised by the researcher. The average scores of Limited Trial Phase II for the multimedia electronic magazine in each aspect are presented in Table 11 below.

Table 11. Recapitulation of the Average Results of Student Respondents in Limited Trial Phase II

No.	Assessment Item	Mean Score	Category
	Content Aspect		
1.	The biotechnology material presented in the multimedia electronic magazine helps students achieve learning objectives	3.54	SB
2.	The material and examples of biotechnology products presented in the multimedia electronic magazine are related to daily life	3.51	SB
3.	The images, videos, and audio presented in the multimedia electronic magazine are relevant to biotechnology material	3.64	SB
4.	The information presented in the multimedia electronic magazine is easy to understand	3.54	SB
	Average	**3.55**	**SB**
	Attractiveness Aspect		
5.	The overall design appearance of the multimedia electronic magazine is attractive and not monotonous, increasing my interest in learning biotechnology material	3.52	SB
6.	The color composition used in the multimedia electronic magazine is very appropriate, not too striking, and does not interfere with visual comfort	3.53	SB
7.	The display of images, videos, and audio presented in the multimedia electronic magazine is clear and attractive	3.50	SB
8.	The multimedia electronic magazine provides new information/knowledge and new learning experiences through the use of an electronic magazine, making learning more enjoyable	3.57	SB
	Average	**3.53**	**SB**
	Effectiveness Aspect		
9.	The multimedia electronic magazine on biotechnology material is organized in a systematic and clear format	3.53	SB
10.	The instructions for using the multimedia electronic magazine are presented clearly and do not confuse users	3.56	SB
11.	The language used in the multimedia electronic magazine is simple, clear, and easy to understand, enabling me to understand biotechnology material well	3.46	SB
12.	The type and size of the font used in the multimedia electronic magazine are very appropriate and easy to read	3.58	SB
13.	The multimedia electronic magazine on biotechnology material can be used without special expertise	3.65	SB
14.	The use of buttons/navigation in the electronic magazine is easy to operate on various electronic devices	3.60	SB
	Average	**3.56**	**SB**
	Overall Average Score of All Aspects	**3.55**	**SB**

Based on the results of the Stage II limited trial conducted with students, an overall mean score of 3.55 was obtained, categorized as Very Good (VG). In the content aspect, the indicator with the highest score was component 3, with a mean score of 3.64, which falls into the Very Good (VG)

category. Meanwhile, the indicator with the lowest score was component 2, with a mean score of 3.51, also categorized as Very Good (SB).

In the attractiveness aspect, the indicator with the highest score was component 8, with a mean score of 3.57, which is included in the Very Good (SB) category. The indicator with the lowest score in this aspect was component 7, with a mean score of 3.50, categorized as Very Good (SB). Meanwhile, in the effectiveness aspect, the indicator with the highest score was component 13, with a mean score of 3.65, which falls into the Very Good (SB) category. The indicator with the lowest score was component 11, with a mean score of 3.46, also categorized as Very Good (SB).

Quality Results of the Multimedia Electronic Magazine

Based on the results obtained from the mean scores of the validation, Stage I limited trial, and Stage II limited trial, the quality of the multimedia electronic magazine can be assessed as follows.

Table 12. Quality of the Multimedia Electronic Magazine

No.	Subject	Average	Category
1.	Validation	3.57	SV
2.	Stage I Trial	3.74	SB
3.	Stage II Trial	3.55	SB
	Average	**3.62**	**SB**

Notes : SV = Very Valid and SB = Very Good

Based on Table 12, it can be concluded that the average quality of the multimedia electronic magazine on biotechnology material is 3.62, which falls into the Very Good (SB) category.

CONCLUSIONS

Based on the conducted research, it can be concluded that the developed multimedia electronic magazine on Grade X senior high school biotechnology material is of very high quality, achieving an average score of 3.62. This is supported by the validation results of the material, language, and graphical aspects, which obtained an average score of 3.55 (very valid). The Limited Trial Phase I obtained an average score of 3.74 (very good), and the Limited Trial Phase II obtained an average score of 3.55 (very good).

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