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Development of an Interactive E-Magazine as a Biology Learning Media to Improve Grade X Students' Understanding of Biotechnology at SMAS Al Ma'shum Kisaran BRT

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ABSTRACT

This study aims to develop an interactive e-magazine as a Biology learning medium to improve the understanding of Grade X students on Biotechnology material at SMAS Al Ma'shum Kisaran BRT. The method used is research and development (R\&D) with the 4D model (Define, Design, Develop, Disseminate) by Thiagarajan. Data were collected through observation, interviews, questionnaires, expert validation, and trials involving students and teachers. The validation results showed that the developed media is highly valid, with an average percentage of 95% (96% for media aspects and 94% for material aspects). The practicality test scored 83% from students and 90% from teachers, which is considered very practical. The effectiveness test showed an average N-Gain score of 0.72 (72%) in the high category. The e-magazine is equipped with interactive features such as videos, quizzes, and a virtual lab, and presents the material in a contextual and visually appealing way. Therefore, this interactive e-magazine is feasible to be used as a learning medium that supports students' understanding and the implementation of the Merdeka Curriculum.

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1. INTRODUCTION

Education is a primary means for individuals to develop their potential through the learning process (Fitri, 2021). It plays a crucial role in eradicating ignorance, combating poverty, improving the standard of living, and enhancing the dignity of a nation (Pristiwanti et al., 2022; Sanga & Wangdra, 2023). Efforts to improve the quality of education in Indonesia have been made through various strategic steps, including the provision of facilities and infrastructure, curriculum revision, teacher competency enhancement, and refinement of assessment systems (Hanifah et al., 2020). In this context, educational quality is not solely determined by policies but also by their implementation in the field, which requires collaboration among teachers, students, and parents.

In the learning process, teachers are not merely conveyors of content but must also be capable of designing creative and innovative learning experiences to enhance students' interest and innovative learning experiences to enhance students' interest and understanding (Anggreini & Priyojadmiko, 2022). According to Hapsari & Fahmi (2021) teachers must utilize available technology to create engaging instructional media. Such media not only help students grasp material more easily but also improve motivation, learning interest, critical thinking skills, and active participation in learning activities (Ndraha & Harefa, 2023; Ni'mah & Hermiati, 2022; Sari et al., 2023; Wibowo, 2023).

Instructional media are essential components that must be provided by every educational institution as part of efforts to ensure effective and quality teaching and learning. The Directorate of Higher Education under the Ministry of National Education outlines the benefits of instructional media as follows: (1) Standardizing the delivery of content, (2) Making learning clearer and more engaging, (3) Enhancing interactivity, (4) Saving time

and effort, (5) Improving learning outcomes, (6) Enabling flexible learning, (7) Fostering positive attitudes in students, and (8) Transforming the teacher's role to be more productive (Wulandari & Afriansyah, 2019).

With the advancement of technology, various innovations have emerged in the field of education, including technology-based instructional media. One such innovation is the electronic magazine (E-magazine). An E-magazine is a digital version of a magazine, presented in file or website format that can be accessed through electronic devices such as computers, laptops, smartphones, and other technologies (Azzah, 2023). E-magazines are also cost-effective as they do not incur printing and distribution costs like conventional media (Azka, 2024).

In educational settings, E-magazines help create a conducive learning environment, encourage independent learning, and assist students in .focusing better on the subject matter (Akbar & Mukminan, 2019; Rifqiawati et al., 2020) E-magazines are visually appealing and are often equipped with images, animations, and videos that attract learners' attention (Sania et al., 2024; Triana, 2023). The interactive elements in E-magazines also promote student engagement in the learning process, thereby enhancing their comprehension (Raihan & Rizqi, 2024; Rauwers et al., 2018). E-magazines as instructional media align well with contextual learning approaches that emphasize connecting learning material with students' real-life experiences (Lestari et al., 2024).

Numerous studies have demonstrated that the use of technology-based learning media, such as biology magazines, can significantly improve student learning outcomes. According to Hastini & Tanjung (2022), the use of biology magazines led to a significant increase in students' understanding, with an N-Gain score of 0.72. Additionally, Ma'rifah (2017) reported that a website-based E-magazine developed for biology instruction could enhance students' critical thinking skills. Melinda (2021) also found that the use of E-magazines significantly improved students' conceptual understanding of electrolyte and nonelectrolyte solutions.

At SMAS Al Ma'shum Kisaran BRT, especially in biotechnology instruction, several challenges persist, including the lack of appropriate learning resources that cater to students' needs. Preliminary observations revealed key issues in the teaching of biotechnology. Interviews with biology teachers indicated that many students struggle to grasp complex biotechnology concepts. The interviews also pointed to the lack of adequate learning resources as a major barrier. Commonly used media, such as textbooks and posters, are perceived as insufficient for helping students understand biotechnological processes in depth. Moreover, the predominance of lecture-based methods leads to passive learning, with some students appearing disengaged or even sleepy during lessons. Although teachers have attempted to incorporate simple practical activities, students still struggle to connect theoretical knowledge with real-world applications.

Furthermore, a questionnaire distributed to 30 Grade X students revealed that 70% found biotechnology material difficult to understand. Although various learning media are available, 90% of the students reported that textbooks were still the most commonly used. However, 100% of the students expressed a preference for media containing visuals, videos, and engaging storylines. Additionally, 66.7% of the students showed interest in digital media such as E-magazines, videos, or e-learning platforms. In light of these findings, the researcher proposes the "Development of an Interactive E-Magazine as a Biology Learning Media to Improve Students' Understanding of Biotechnology in Grade X at SMAS Al Ma'shum Kisaran BRT." This development is expected to serve as an innovative solution to enhance student engagement and improve conceptual understanding more effectively

2. RESEARCH METHOD

This research was conducted from February to May 2025, with the research subjects being Grade X students at SMAS Al Ma'shum Kisaran BRT. The type of research used was research and development (R&D) employing the 4D model (Four-D). According to Thiagarajan et al. (1974), this model consists of four main stages: Define, Design, Develop, and Disseminate.

In the Define stage, a needs analysis was carried out through observations and interviews to identify existing problems and determine the characteristics of students as the target of the interactive e-magazine development on biotechnology. The Design stage involved drafting a storyboard and initial prototype by considering visual aspects, navigation, and content suitability. The Develop stage included the creation of the interactive e-magazine product, which was then validated by media and material experts before being tested by users. The Disseminate stage was not conducted due to time and access limitations. However, evaluation and revision were still carried out to ensure product quality before further implementation

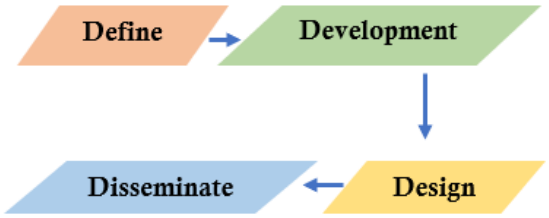

Figure 1. 4D Research Model Flow
Source: Thiagarajan et al. (1974)

Research Instruments

The instruments used in this study covered several data collection techniques. In the analysis stage, observations and interviews were conducted to identify field conditions, encountered problems, and potential alternative solutions. Additionally, a student questionnaire was administered to gather information about the learning media used and their learning outcomes.

To evaluate the validity of the product, validation sheets were used—assessed by both material and media experts. Response questionnaires were also distributed to teachers and students to collect their feedback regarding the appeal of the interactive e-magazine as a learning medium. Finally, a test consisting of 15 items (10 multiple choice and 5 essay questions) was administered to evaluate the effectiveness of the interactive e-magazine, involving Grade X students of SMAS Al Ma'shum Kisaran BRT.

Data Analysis Techniques

The data analysis techniques in this study consisted of validity testing, practicality testing, and effectiveness testing. Each test was analyzed using appropriate methods to ensure the quality of the interactive e-magazine as a biotechnology learning medium.

a. Validity Test

Data from expert validation and teacher/student responses were analyzed using a Likert scale. The data obtained from the expert validation sheets and response questionnaires were calculated based on the average score for each assessed indicator.

Table 1. Scoring Guidelines for Response Questionnaires and Validation Sheets

Assessment	Score
Very Good (VG)	5
Good (G)	4
Fair (F)	3
Poor (P)	2
Very Poor (VP)	1

Source: Sugiyono in Salsabella et al. (2023)

Score Percentage (%) = (Total Score / Maximum Score) × 100

The resulting percentage value was then interpreted based on the validity level criteria presented in Table 2 below:

Table 2. Validity Criteria for the E-Magazine

Assessment	Percentage (%)	Description
Not valid	0–20	Needs revision
Less valid	21–40	Needs revision
Fairly valid	41–60	Needs revision
Valid	61–80	No revision needed
Very valid	81–100	No revision needed

Source: Hendayani (2019)

b. Practicality Test

The practicality of the product was assessed based on response questionnaires completed by teachers and students after using the interactive e-magazine in the learning process. Data from the questionnaires were analyzed by calculating the score percentage to determine how easily the media could be used and accepted by users.

Table 3. Practicality Criteria for the E-Magazine

Assessment	Percentage (%)
Not practical	0–20
Less practical	21–40
Fairly practical	41–60
Practical	61–80
Very practical	81–100

Source: Hendayani (2019)

c. Effectiveness Test

To assess the effectiveness of the interactive e-magazine, an analysis of the improvement in students' learning outcomes was conducted using the normalized gain (N-Gain) formula. The improvement before (pretest) and after (posttest) using the media was analyzed as follows:

Normalized Gain (N-Gain) = (Posttest Score - Pretest Score) / (Maximum Score - Pretest Score)

Table 4. Effectiveness Criteria for the E-Magazine

Average N-Gain	Classification	Description
N-Gain ≥ 0.7	High	Effective
0.3 ≤ N-Gain < 0.7	Medium	Moderately Effective
N-Gain < 0.3	Low	Less Effective

Source: Hendayani (2019)

3. RESULT AND DISCUSSION

Define Stage

The results of the observations and needs analysis at SMAS Al Ma'shum Kisaran BRT revealed several challenges in biotechnology instruction, including limited learning resources and a lecture-dominated teaching approach, which led to students being less engaged. Interviews with biology teachers highlighted difficulties in understanding abstract concepts such as genetic engineering and fermentation without adequate visual media support. A questionnaire distributed to 30 Grade X students showed that 27% experienced difficulties learning biology, 23% had felt bored, and 70% considered biotechnology to be a challenging topic. Despite the availability of various learning media, 90% of students reported that printed books were the most frequently used, whereas 100% preferred media with appealing visuals and storytelling elements, and 66.7% expressed interest in digital media such as e-magazines, videos, or e-learning. The e-magazine emerged as a preferred medium that aligns with students' learning preferences.

Design Stage

In the design stage, an initial product plan was developed in the form of a storyboard to guide the development of the biology e-magazine. The design focused on layout and content, including a magazine template with key elements such as an introduction, content presentation, evaluations, and supporting features designed to enhance learning effectiveness.

Development Stage

At the development stage, the e-magazine was designed using the Canva platform, then converted into an interactive digital medium through Heyzine Flipbooks, and subsequently presented in the form of a website link accessible to users. Presenting the media as a website link was also intended to facilitate easy access for students and other users. This format allows the media to be accessed anytime and anywhere, including via smartphones. This is in line with the findings of Martahan & Nasution (2023), who reported that e-magazines in the form of website links enable readers to access learning materials more easily, without requiring much time or cost.

Furthermore, the media was developed with reference to the learning outcomes and objectives of Grade X Biology. This alignment supports Astuti & Zulkarnain (2019) assertion that the integration of content, basic competencies, indicators, and learning objectives plays a crucial role in ensuring the clarity of information delivered, thereby shaping conceptual understanding appropriate to students' cognitive levels. The development process also took into account input from Biology teachers obtained through interviews. This stage included validation by media and content experts, practicality testing based on feedback from students and teachers, and media trials to assess the effectiveness of the e-magazine in enhancing students' understanding. The results of each type of test are presented in the following tables.

Table 5. Validation Results of the E-Magazine by Media and Content Experts

Aspect	Assessment Item	Number of Items	Score Obtained	Percentage	Validation Score	Criteria
Media	Magazine Layout	4	19	95%	**95%**	**Very Valid**
	Presentation Technique	3	15	100%		
	Interactivity	3	14	93%		
	Media Avg.			**96%**		
Content	Material Scope	2	9	90%		
	Presentation Technique	6	28	93%		
	Contextual Relevance	2	10	100%		
	Content Avg.			**94%**		

Media validation was conducted to assess the feasibility of the developed e-magazine before it was implemented with students. According to Dewi (2018)validation testing is used to measure the precision and accuracy of a product, in this case, an interactive e-magazine. The validation results, as shown in Table 4, indicate that the e-magazine falls into the "Highly Valid" category, with an average percentage score of 94%, covering both visual presentation and content quality. Specifically, the media aspect received a validation score of 96%, while the material aspect scored 92%. These results suggest that the developed e-magazine meets the required standards in terms of visual design, systematic presentation, interactivity, and the delivery of biotechnology content that is comprehensive, clear, and contextualized to students' everyday experiences.

The following is a display of the developed media:

Figure 2. Front Page Display of the Media: (a) Cover View, (b) Information and Table of Contents

Figure 3. Content Display of the Material

Figure 3 displays the content layout of the developed media. The material is presented using concise, straightforward language that is easy for students to understand. In addition, the media is equipped with supplementary information such as “Fun Fact” or “Did You Know” sections, aimed at broadening students’ knowledge and fostering their interest in the topic. To strengthen understanding, instructional videos are also provided and can be directly accessed by students to reinforce their grasp of the material. Such presentation supports a more engaging and effective learning process. This is in line with the statement by Alifah et al. (2022, as cited in Septiani et al. 2024), that teachers need innovative learning media that include videos and other supporting content aligned with the subject matter to facilitate the delivery of learning materials to students.

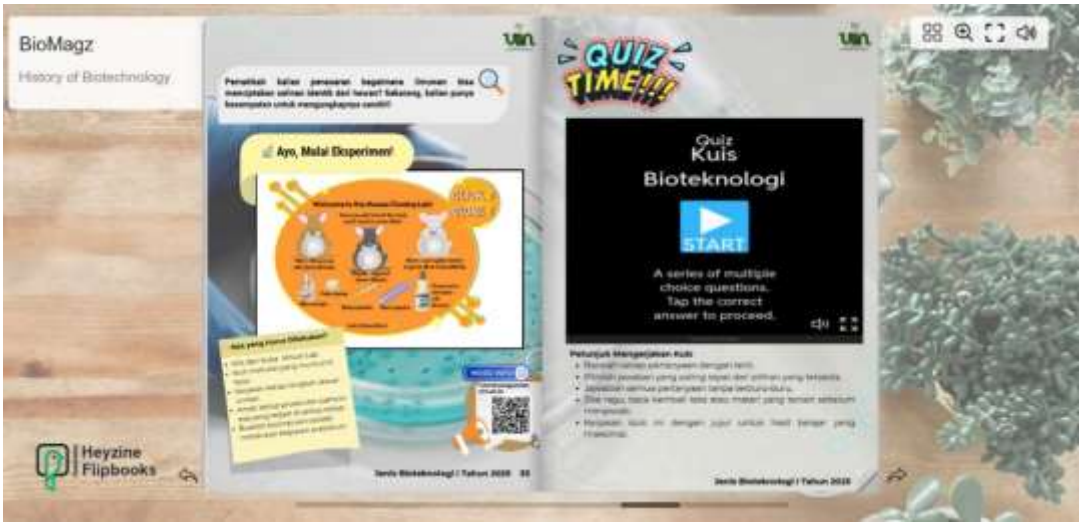

Figure 4. Display of the Media’s Interactive Activities

Figure 4 illustrates the interactive features embedded within the media, such as quizzes and virtual labs that can be accessed by students. These features are designed to enhance conceptual understanding and encourage active student engagement in the learning process. This is supported by Hanisah et al. (2022), who state that the presentation of material in a complete and systematic manner facilitates more effective delivery of core concepts, and that the availability of summative test questions at the end of the material can provide valuable feedback. Furthermore, a practicality test was conducted by both students and teachers to evaluate the usability and functionality of the media.

The practicality of the media was evaluated through questionnaires completed by students and teachers

Table 6. Practicality Test Results by Students and Teacher

Respondents	Number of Statements	Score
Students (n;30)	10	41.4
Teachers	10	48
	Total Score	**89.4**
	Percentage	**89%**
	Criteria	**Very Practical**

The practicality test of the learning media conducted with students (Table 5) resulted in an average score of 41.4 out of a maximum of 50, equivalent to 83%, which falls into the "highly practical" category. This indicates that the media effectively facilitates students' understanding of abstract biotechnology concepts through engaging visual presentations and communicative language. In addition, the practicality test conducted by teachers showed a percentage score of 90%, indicating that the media is highly suitable for classroom needs. The media also supports the implementation of the Merdeka Curriculum by providing an interactive and contextual self-learning tool, thereby assisting teachers in delivering more effective and relevant instruction. Subsequently, a product effectiveness test was carried out using pre-designed test instruments. The tests were administered before and after the implementation of the media to the students. The results are presented in Figure 5.

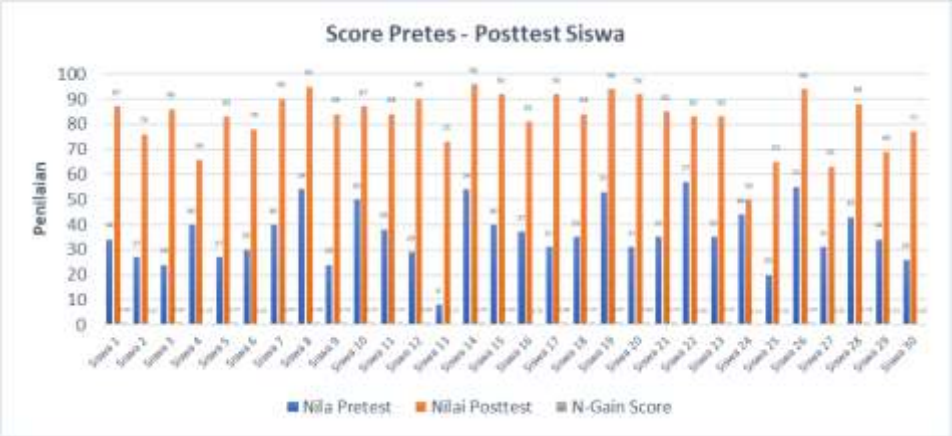

Figure 5. Comparison of students' pretest and posttest scores after the implementation of the e-magazine.

Finally, the data from the effectiveness test were analyzed using Microsoft Excel with the N-Gain formula. The calculation results are presented in Table 7.

Table 7. Results of the Effectiveness Test of the Developed E-Magazine Based on N-Gain Analysis

Aspect	Average Score	Max Score	N-Gain Score	Criteria
Pretest	36.20	100	0.72	High / Effective
Posttest	82.23	100		

Based on the data in Table 7, the N-Gain score obtained was 0.72 or 72%, which falls into the high (effective) category (Hake, 1998). This finding indicates that the use of the E-Magazine has a positive impact on improving students' understanding of biotechnology concepts. These results are consistent with the study by Hastini & Tanjung (2022) which showed a significant increase in students' comprehension through the use of a biology magazine with an identical N-Gain score. Similarly, Ma'rifah (2017) stated that a web-based E-Magazine can empower students' critical thinking skills, while Melinda (2021) found that such media can improve conceptual understanding in the topic of electrolytes and non-electrolyte solutions.

Moreover, the bar chart in Figure 5 illustrates a relatively even distribution of N-Gain scores among students. This indicates that although most students experienced consistent improvement, there were some who showed less optimal or even below-average progress. Observations and reflections on the implementation of the pretest and posttest revealed that some students did not complete the test earnestly. A number of students appeared to answer carelessly, as evidenced by extremely short completion times, seemingly random answer choices, and mismatches between the difficulty level of the questions and the selected answer

4. CONCLUSION

Based on the results of the validation, practicality, and effectiveness tests, it can be concluded that the developed interactive e-magazine is feasible to be used as a learning medium for Biology, specifically in the topic of Biotechnology. The validation results indicate a "highly valid" category with an average percentage of 94%. The media was also rated as "highly practical" by students (83%) and teachers (90%). The effectiveness test showed an N-Gain score of 0.72 or 72% (high category), indicating a significant improvement in students' understanding. With its visually engaging design, contextual content, and interactive features, this e-magazine supports self-directed learning and aligns well with the implementation of the Merdeka Curriculum.

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