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Development of an E-Booklet Utilizing Endophytic Fungi Isolated from Phalaenopsis amabilis Roots to Enhance Learning Outcomes on Kingdom Fungi Material

Sri Wulandari, *Dwi Sucianingtyas Sukamto, Hanif Rafika Putri
Biology Education Department, Faculty of Teacher Training and Education, PGRI Argopuro University Jember. Jl. Jawa No.10, Tegal Boto Lor, Jember Regency 68121, Indonesia.
*Corresponding Author e-mail: dwisucianingtyas2310@gmail.com

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Abstract

This study aims to develop an E-Booklet utilizing endophytic fungi isolated from the roots of *Phalaenopsis amabilis* to improve learning outcomes of Kingdom Fungi material for class X MA Zainul Bahar students, Bondowoso. The research method used is the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The isolation results show a diversity of endophytic fungi that are potentially authentic learning resources. This e-booklet is organized in an interactive and contextual manner, integrating isolation result data into teaching materials that are in accordance with the Merdeka Curriculum. The novelty of this research lies in the utilization of endophytic fungi from the roots of P. amabilis as a source of local content that has not been widely explored in learning media. In addition, the use of the E-Booklet format based on original research data provides added value in the form of a scientific approach directly from the field, which is not yet available in conventional learning resources. This study involved 27 grade X students using the one-group pretest-posttest design method and an expert validation test. Validation by experts gave the material a score of 91% (very valid) and media 87% (very valid), while the practicality test based on student questionnaires reached 85% (practical). N-gain analysis of 0.82 (high category) shows that this E-Booklet effectively improves students' learning outcomes on the Kingdom Fungi material.

Keywords: Development; E-Booklet; Endophytic Fungi; Learning Outcomes; ADDIE

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INTRODUCTION

The development of Information and Communication Technology (ICT) has a positive impact on the development of learning media in teaching and learning. Technological advancements provide vast opportunities that not only bring convenience but also bring new challenges for humans living in this era. The advances that occur create challenges for teachers to adapt to situations that are easy, fast-paced, and digital (Widiari *et al*, 2023). According to research conducted by Idayanti and Suleman (2024) stated that in addition to technology, the results of scientific research also play an important role for teachers in teaching material that is evidence-based and in accordance with scientific advances. This is in line with the independent curriculum program to create a generation of lifelong learners who have the personality of Pancasila students, as well as preparing students for the learning process, such as learning outcomes and reconstructing scientific concepts.

In this regard, of course, in 21st-century learning, all educators are expected to be able to make changes or new innovations in the field of education. Some obstacles are found such as

teaching materials usually delivered in the form of reading which is not easily understood thoroughly by students, of course teachers need teaching materials that are in accordance with the characteristics of students and the applicable curriculum, so that learning can be carried out optimally (Arrohman *et al*., 2022). Teaching materials, in addition to helping educators, of course, also help students to better understand the material so that learning objectives can be achieved. The lack of teaching materials available in education can affect student learning outcomes (Sinaga and Situmorang, 2023).

Most students experience a decrease in interest and motivation to learn because teachers tend not to utilize various forms of interactive multimedia in learning. This is in line with the results of research by Bulan and Imansyah (2023), which shows that the majority of educators are constrained by limited multimedia training or workshops, especially those related to the development of interactive digital learning media. Similar problems are also found globally. According to Huang *et al*. (2021), the use of attractive and visually based digital media can increase student engagement and understanding, especially in abstract and complex science learning.

Based on observations made at MA Zainul Bahar, it was found that in the Biology learning process, especially in the Kingdom Fungi material, students considered the material difficult and boring. This is exacerbated by the lack of learning media used, limited learning resources that only rely on teacher books and student books, and the results of scientific research, especially on endophytic fungi from local flora, have never been utilized as alternative learning resources. As a result, students cannot learn optimally and are less involved in the latest scientific developments. Another phenomenon found is the low student learning outcomes in Biology. This finding is in line with a study by Muthmainnah *et al*. (2022) which states that the low utilization of innovative learning media has a significant impact on student learning outcomes.

Biology learning material for class X in the odd semester, one of which is the kingdom of fungi. Fungal material studies the characteristics of fungi from macroscopic to microscopic. The fungi that will be introduced in this study are endophytic fungi isolated from the roots of P. *amabilis*. P. *amabilis* is a monopodial epiphytic orchid that originated and spread in Indonesia, this plant is rich in microorganisms, especially endophytic fungi that play a role in mutualistic symbiosis (Sukarno, 2023). The research results of Winangun, I. M. A. (2024) revealed that by utilizing the potential of local flora as a learning resource, it is hoped that students will get more accurate and accountable information so that students can appreciate learning more and become more ready to play an active role in environmental conservation, because they have direct knowledge built through real experience. To find out the type of endophytic fungi that are symbiotic on this plant, an isolation process is needed. Isolation is the process of taking or separating natural material compounds using an appropriate solvent, and then the identification process is carried out based on the characteristics of the colonies and microscopic morphology is cultured to determine the species (Dwi Rahayu, N., *et al*, 2024). The breadth of information in this fungi material is not matched by a proportional allocation of learning time in the classroom, so that in delivering fungi material, teaching media is needed that can support the learning process. To anticipate time constraints, and be able to display microscopic and macroscopic forms of fungi. One of them is the use of E-Booklet learning media.

E-Booklet is a learning media developed. In general, the term booklet is a combination of book and leaflet. Booklets in digital form, or often referred to as E-Booklets, include information that can be accessed through electronic devices such as cellphones and laptops, so this format is expected to be more practical to use. The use of E-Booklet media as learning utilizes electronic media to introduce its contents in a concise, interesting, and easy-to-use manner. The informative nature of the E-Booklet and also its attractive design can trigger curiosity in students. students can also understand the material in the E-Booklet repeatedly

because it is very simple so that students can access the E-Booklet anywhere and anytime (Violla, R., & Fernandes, R. 2021). This e-booklet will be used as a learning tool that contains information about the material and products of the learning process. The material that will fill this learning media is Kingdom Fungi material, especially the utilization of endophytic fungi isolated from the roots of Phalaenopsis amabilis as a learning resource.

Based on recent research Lestari, T., & Nurtamara, L. (2024) stated that the use of E-Booklets in learning biology at the high school level increased student understanding by 89%, because it combines technology with a visual approach that is stronger than traditional print media. Previous studies tend to use general or textbook-based materials, while the development of E-Booklets in this study is based directly on the results of scientific research conducted by researchers, so it is original and authentic. Thus, the gap that this research tries to bridge is the absence of E-Booklet media that integrates actual research results on endophytic fungi from local flora as biology teaching materials, especially in Kingdom Fungi material.

Based on the description above and the results of direct observations made at MA Zainul Bahar Bondowoso indicate that the lack of use of learning media and low student learning outcomes. Therefore, this study aims as follows: 1) describe the feasibility of E-Booklet learning media utilizing endophytic fungi isolated from the roots of *Phalaenopsis amabilis*. 2) describe the improvement of student learning outcomes.

METHOD

Research Method and Approach

This research uses a Research and Development (R&D) approach with the ADDIE model developed by Robert Maribe Brack which focuses on development for learning purposes, one of which is learning media by describing a systematic approach to instructional development consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. Each stage is designed to ensure that the learning media developed meets user needs and is effective in the learning context (Muliyani, R., *et al*., 2024). The ADDIE development model can be seen in Figure 1.

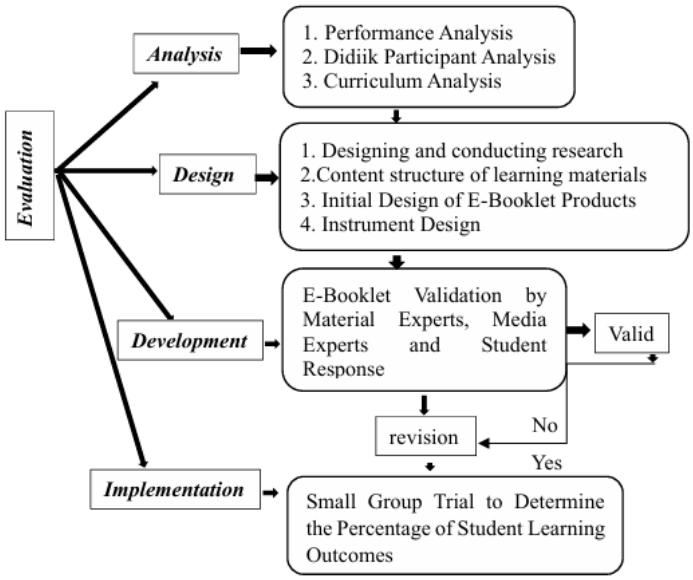

Figure 1. Stage of ADDIE Research Procedure (Putri *et al*, 2024)

Analysis Stage

At this stage, the researcher evaluates the aspects that form the basis of product development, and assesses the feasibility and requirements of development. This analysis was

conducted at MA Zainul Bahar, Bondowoso, including performance analysis, learner analysis and curriculum.

Performance analysis. This analysis was conducted to obtain relevant information about the biology learning process at school, the availability of learning resources, and the condition of students during the learning process. At this stage, researchers interviewed biology teachers in MA and distributed questionnaires to understand the needs of students.

Learner Analysis. Learner analysis is needed to understand the characteristics, needs, and learning readiness of students, so that the media or learning strategies developed can be more targeted and effective.

Curriculum analysis. This analysis aims to understand the curriculum applied at school. At this stage, researchers analyzed the teaching modules used, as well as materials and learning objectives. In this study, what was analyzed was Kingdom Fungi material.

Design Stage

At this stage, the author designs learning media products based on the results of the analysis from the previous stage. The product designed is an E-Booklet as a learning media for Kingdom Fungi material utilizing endophytic fungi isolated from P.amabilis roots. In the process of making the design, several activities were carried out, such as compiling learning materials, structuring the content of learning materials and compiling materials.

Designing and conducting research. Before preparing the learning media, researchers conducted laboratory research for the isolation of P. *amabilis* roots. The following is the procedure for isolating the roots of P. *amabilis*. Isolation of endophytic fungi is done by direct planting method. P.*amabilis* along 2 cm was sterilized using 70% ethanol solution for 5 minutes, followed by 5% sodium hypochlorite (NaOCL) solution for 3 minutes, and rinsed with sterile water 3 times. Root pieces were then cross-sectioned and placed on Potato Dextrose Agar (PDA) media in petri dishes and incubated at 26°C for 7 days. Fungal colonies that appear can be identified based on colony morphology, such as color, texture, and shape of the spores formed. After initial identification, the fungi can be isolated separately and transferred to new media to ensure purity.

Structuring the content of learning materials. Compiling material After completing research in the laboratory and collecting data, these results can be incorporated into E-Booklet learning media for Kingdom Fungi material.

Initial Design of E-Booklet Products. Determining the physical aspects of the E-Booklet, including cover design, instructions for use, introduction, e-booklet content, glossary and bibliography.

Instrument Design. Before the product is tested, it will be validated to experts. That way, at this stage researchers design and compile validation instruments, student response questionnaires, pretest and post test questions to complete the media development process.

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Development Stage

At this stage, the products that have been developed are refined through the validation test process. The purpose of this validation is to ensure that the products produced are appropriate and can be used by students. This phase includes the following steps:

Expert validation

At this stage, an assessment of how valid the learning media is. Researchers distributed validation questionnaires to validators to identify weaknesses in the e-booklet. criticisms and suggestions from the validators will be used as a basis for making product revisions. Expert validity involves two lecturers who act as material and media experts.

Trial Subjects

This study involved 27 MA Zainul Bahar class X students as test subjects, consisting of 15 female students and 12 male students with an average age of 15-16 years. subject selection was carried out purposively by considering the availability of classes and the suitability of the material under study, namely Kingdom Fungi material in Biology subjects.

Academically, students in this class have diverse learning ability backgrounds. Based on the previous semester's report card data, 9 students (33%) were in the high category, 13 students (48%) in the medium category, and 5 students (19%) in the low category. The sample size of 27 students in this study was chosen based on the development research (R&D) approach, which focuses on limited trials to determine the feasibility and initial effectiveness of the learning media developed. According to Sugiyono (2016), in development research, limited trials can be conducted in small groups (between 6-30 subjects) to identify product weaknesses before wider trials.

Data Collection Instruments

Data collection techniques in this study were obtained from qualitative and quantitative data. Qualitative data in the form of observations, interviews, needs questionnaires and quantitative data obtained from expert validation questionnaires, student responses and pretest-posttest questions of learning outcomes.

Data Analysis Technique

On the instrument sheet validation of material experts, media experts, and student responses. The validity of the learning media is assessed based on data from the assessment sheet, which uses a Likert scale of 1-5. The following is an explanation of the criteria for each assessment on a Likert scale:

Table 1. Categories of expert validation score interpretation (Adapted from Birru and Takwim (2024)).

Category	score(%)
Very feasible	81%-100%
Feasible	61%-80%
Fair	41%-60%
Not feasible	21%-40%
Very unfeasible	<20%

Table 2. Student response score interpretation categories (Adapted from Yumelda (2022)).

Category	score(%)
Very good	81%-100%
Good	61%-80%
Fair	41%-60%
less	21%-40%
Very poor	<20%

The percentage calculation technique adapted from Akbar uses the following formula:

$P = \frac{\sum \times}{n} \times 100\%$

Description:

P = Percentage of validity

$\sum \times$ = Number of scores obtained by each criterion

n = Maximum number of scores

Products that have been validated by experts will be tested in a limited trial on students studying Kingdom Fungi. To see the improvement of learning outcomes in students, researchers used a one-group pretest-posttest design, items on the pretest and posttest were

arranged in the form of 20 multiple choice questions with five answer options. The preparation of questions is based on Bloom's revised taxonomy, which includes cognitive aspects ranging from C1 (remembering) to C4 (analyzing), in accordance with the learning outcomes on Kingdom Fungi material. Before use, the items were validated by two expert lecturers in biology and learning media to ensure the suitability of content, construction, and language. The validation results showed that the items were feasible to use with minor revisions such as the use of punctuation, more appropriate word selection, or improvement of less effective sentences.

Normality Test

The normality test is used to determine whether the data on student learning outcomes are normally distributed or not. In this study, the normality test was carried out using the Kolmogorov-Smirnov test because the number of samples was more than 20 (N = 27). This test is suitable for interval or ratio scale data that you want to analyze with parametric tests such as the t-test (Priyatno, 2016). Mathematically, the Kolmogorov-Smirnov test is formulated as follows:

$$D = sup\ |Fn(x) - F(x)|$$

Description:
D: Kolmogorov-Smirnov statistical value
sup: supremum, which is the maximum value of the absolute difference.
Fn(x) : empirical cumulative distribution function (sample data)
F(x) : theoretical cumulative distribution function (normal distribution)

N-Gain Improvement Test

This test is used to determine the effectiveness of the treatment given. Analysis of pretest and posttest scores using the normality gain test (N-gain) was chosen because it effectively measures the increase in student understanding before and after learning and can consider differences in students' initial abilities. The following is the formula used to calculate the normality gain:

$$N - gain = \frac{Score\ posttest - pretset}{Score\ maximum - skor\ posttest}$$

The results of the N-gain calculation were interpreted using Hake's classification. The criteria of the N-gain score according to Hake as shown in table 3 below.

Table 3. Criteria for interpretation of student learning outcome scores (Hake, 1998)

Category	N-gain score(%)
High	N-gain ≥ 0,7
Mrdium	0,3 ≤ N-gain < 0,7
Low	N-gain ≤ 0,3

The effectiveness of the E-Booklet is determined according to Table 3 of the N-gain interpretation criteria. If the range of results for the students' pretest and posttest, after analyzing them using N-gain, is 0.3 or higher, it is deemed effective.

RESULTS AND DISCUSSION

Analysis Stage

Performance Analysis

Based on the results of a pre-survey interview with Biology subject teachers at MA Zainul Bahar, it was found that in their lessons teachers still often use printed media and

sometimes also use LKS and teachers have never implemented research-based learning. So that the learning media used is less varied and less following the progress of science.

Learning Analysis

Based on the results of the presurvey of students' needs, it was found that 60.7% of students stated that learning Biology was difficult. The reason students state that learning Biology is difficult is because learning Biology uses scientific language language that is rarely used in everyday life as much as 71.4%. Learners stated that it was difficult to understand the material of the fungi kingdom as much as 82.1%. Students have never studied endophytic fungi obtained from research results so that 57.1% stated that they were very interested in the renewal of kingdom fungi material and 42.9% stated that Biology material needed to be developed to support learning and students wanted independent learning media which included images, videos to make it easier to understand biological material, namely kingdom fungi

Curriculum Analysis

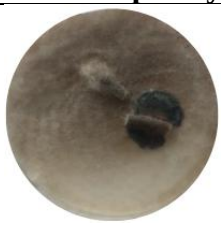
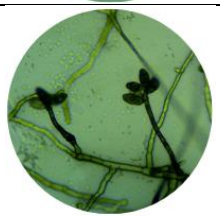
The purpose of doing a curriculum analysis is to gather the essential ideas that will be included in learning media products in line with the requirements of the relevant curriculum. This stage can be utilized as a guide for creating E-Booklet learning materials, as the material chosen is aligned with the curriculum.

Desain Stage

Designing and conducting research

Before designing and compiling E-Booklet learning media, researchers conducted research in the laboratory to isolate P. *amabilis* roots. After conducting research in the biology laboratory and developing E-Booklet learning media utilizing Endophytic Fungi Isolated from *Phalaenopsis amabilis* Roots, the results of macroscopic and microscopic identification were obtained as shows in Table 4.

Table 4. Endophytic fungi macroscopically and microscopically

Genus	macroscopically	microscopically
Rhizoctonia sp		
Fusarium sp		
Curvularia sp		

Content Structure of Learning Material

At this stage, the researchers developed the E-Booklet in accordance with the teaching module and Learning Plan that had been prepared, namely fungi from the isolation of P.*amabilis* roots. The following is the content of the material:

Table 5. Content Structure of Learning Materials

No	Material	Content
1.	Introduction to Kingdom Fungi	a. General characteristics of Kingdom Fungi b. The role of fungi in the ecosystem c. Main classification of Kingdom Fungi
2.	Isolation and Identification Methods of Endophytic Fungi	a. Fungal isolation technique from P.*amabilis* roots b. Morphological identification of fungi
3.	Endophytic Fungi and Symbiosis with P.*amabilis* Roots	a. Definition of endophytic fungi b. Types of endophytic fungi in P.*amabilis* roots c. The role of endophytic fungi in the growth of P.*amabilis*

Initial Design of E-Booklet Product

At this stage, the design begins in the form of a summary or Storyboard to facilitate product manufacturing

Table 6. Media Design Creation

Page	Content
Cover	1. University Logo 2. Title 3. Image 4. Researcher Identity
Instructions	E-Booklet Instructions for Use
Introduction	Introduction (Introduction to Kingdom Fungi)
E-Booklet Contents	1. Definition of Endophytic Fungi 2. Video on the role of endophytic fungi 3. Isolation and Identification Methods of Endophytic Fungi 4. Endophytic Fungi Identification Results 5. Endophytic Fungi and Symbiosis with P.*amabilis* Root
Glossary	Contents Glossary
Bibliography	Bibliography Details

The process of making E-Booklet learning media Kingdom Fungi Material (Fungi isolate results P. *amabilis* begins with designing the appearance of the media. The cover display is a display that will be seen when students start accessing learning media (Figure 2).

Figure 2. Cover Design of E-Booklet Learning Media

The introduction display is an introductory display before entering the material. The introductory display can be seen in Figure 3.

Figure 3. Introduction of E-Booklet Learning Media

The material display is a representation that contains material from each sub discussed on each page of the E-Booklet. The content display can be seen in Figure 4.

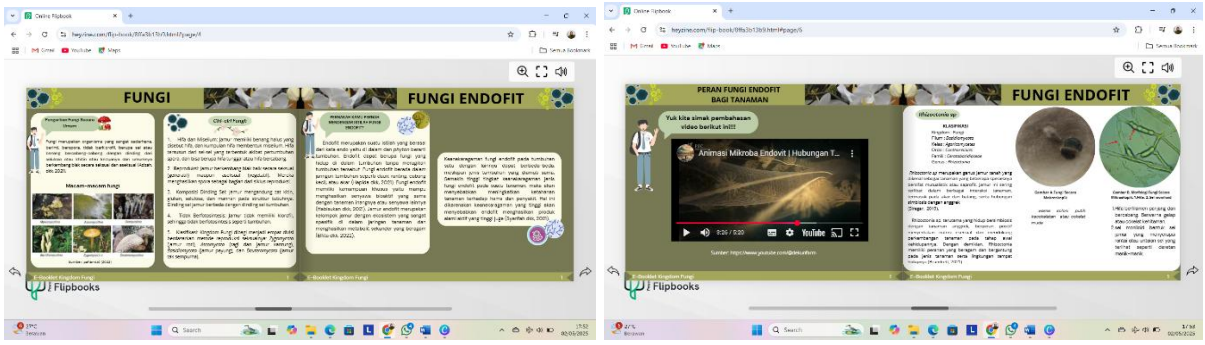


Figure 4. Display of E-Booklet Learning Media Material Content

Lastly, before the product is tested, it validated to experts. That way, at this stage researchers design and compile validation instruments student response questionnaires, pretest and post test questions to complete the media development process.

Development Stage

The assessment of E-Booklets by validators is crucial to evaluate the quality of the products developed by researchers.This assessment was carried out to determine student responses and the validity of the E-Booklet developed.

Table 7. Material Expert Validation Analysis Results

No	Indicator	Score	Category
1.	The suitability of the material with the learning outcomes and objectives learning objectives	96%	Very Feasible
2.	Suitability of the material according to the level of student development	94%	Very Feasible
3.	Clarity of material is easy to understand	91%	Very Feasible
4.	Material presented according to the latest / latest developments	89%	Very Feasible
5.	Readability and Communicability Aspects	85%	Very Feasible
	Total Average Score		**91%**

The results of material validation by experts gave a score of 91%, indicating that the integration between the scientific content of endophytic fungi from the roots of P. *amabilis* with Kingdom Fungi material is considered feasible and enriches students' understanding (as seen in Table 7). However, some notes were still found, such as the need to simplify scientific terms to make it easier for students to understand, which shows the importance of maintaining a balance between scientificity and language affordability.

Table 8. Media Expert Validation Analysis Results

No	Indicator	Score	Category
1.	The design of the E-Booklet media display is attractive and aesthetically pleasing.	92%	Very Feasible
2.	Media capabilities Accuracy in the use and size of fonts and the layout of text and videos on the media	85%	Very Feasible
3.	The choice of colors used does not interfere with student focus	87%	Very Feasible
4.	The attractiveness of media can foster motivation as well as student learning outcomes	83%	Very Feasible
5.	E-Booklets as learning media allow students to access material more flexibly and can be studied anywhere.	88%	
	Total Average Score	**87%**	

The results of media validation by experts gave a score of 87% with a very feasible category. Visualization of endophytic fungi is considered to strengthen students' memory because it is authentic and contextual. However, there was input regarding the discussion of the types of endophytic fungi, images of fungal colonies dominate almost the entire page so that the explanatory text becomes difficult to read. This section was revised by reducing the size of the image and adding a semi-transparent white background behind the text to improve readability.

Table 9. Results of Student Response Analysis

No	Indicator	Score	Category
1.	E-Booklets make learning less boring	87%	Very good
2.	The appearance of the E-Booklet is attractive	83%	Very good
3.	E-Booklets can be used as self-study media	80%	Good
4.	Information on materials and videos provide new knowledge	88%	Very good
5.	E-Booklets are practical and easily accessible anywhere.	87%	Very good
	Total Average Score	**85%**	

Student responses scored 85% with a very good category, students responded that the E-Booklet made the Kingdom Fungi material more interesting and easy to understand because it was presented with real examples and interesting visuals. However, some students also expressed the desire for this media to be equipped with interactive features such as quizzes.

Implementation Stage

Products that have passed expert validation were implemented in the learning process as teaching media that will be used to be tested on students. Field trials were conducted on a limited basis to 27 students who studied kingdom fungi material and data analysis was carried out with normality tests and N-Gain.

Normality Test Results Pretest and Posttest Scores The normality test is carried out using the Kolmogorov Smirnov test to determine whether the residual values are normally distributed or not. The basis for decision making in this normality test is if the significance value is> 0.05,

then the residual value is normally distributed, but if the significance value is> 0.05, then the residual value is normally distributed.

Tabel 10. Results of the Normality Test of Pretest and Posttest Learning Outcomes

		Unstandardized Residual
N		27
Normal Parameters[a,b]	Mean	0.000000
	Std. Deviation	5.542010
Most Extreme Differences	Absolute	0.241
Test Statistic	Positive	0.241
	Negative	-0.169
		0.241
Asymp. Sig. (2-tailed)		0.074

Based on Table 10, it can be seen that the significance value on the pretest and posttest, the sig (2-tailed) result is 0.074>0.05. This shows that the results of the normality test of pretest and posttest data scores are normally distributed. The data in the table below shows the analysis of the N-gain calculation to measure the increase in student learning outcomes after the E-Booklet learning media experiment.

Table 11. Small Group N-Gain Test Analysis Results

Average value		**Magnitude of Improvement**	***N-Gain***	**Highest score**		**Lowest Score**	
Pretest	*Posttest*			*Pretest*	*Posttest*	*Pretest*	*Posttest*
42,01	89,60	47,59	0,82	65	100	15	55

Based on Table 11, it shows that learning the kingdom fungi material with the average student score before using the E-Booklet is 42.01 and after using the E-Booklet is 89.60. From the results of the Pretest and posttest scores, students can see the difference. Based on the N-Gain analysis, student learning outcomes show a value of 0.82 with a high category, meaning that learning by using E-Booklet is able to improve student learning outcomes. it can be concluded that there is a significant difference between learning outcomes before and after using E-Booklet.

The purpose of this study is to improve the learning outcomes of learners with the use of media that has been developed which is in accordance with research conducted (Baunsele *et al.*, 2023) that the quality of education is influenced by various factors, including the quality of learning media that can inspire learners to learn. Based on the results of previous research, it can be concluded that the use of learning media is proven effective in improving learner learning outcomes and developing 21st century skills. These results are in line with previous research that shows the importance of the quality of learning media in improving the quality of education. Nevertheless, further research is still needed to overcome the existing limitations and develop more innovative learning media.

E-Booklet learning media utilizing endophytic fungi isolated from the roots of P. *amabilis* was prepared to solve the research problem of improving student learning outcomes. It contains detailed material content wrapped in unique and interesting graphics that make students interested when using it. From passing the testing process from material and media expert validators, it shows that the E-Booklet learning media is suitable for testing in the field. In addition, from the feasibility test by media experts, a presentation of 91% from material experts, 87% from media experts and student responses with a score of 85% so that it can be said that the media is very feasible and practical.

Analysis of research data shows that the use of E-Booklet learning media utilizing endophytic fungi isolated from the roots of P. *amabilis* has a significant positive impact on improving student learning outcomes on Kingdom Fungi material. The results of the study with the Kolmogorov Smirnov test revealed that in Table 1 the value of Asymp.Sig. (2-tailed) was found to be 0.000, which is less than 0.05. Therefore, it can be concluded that the use of E-Booklet media has an impact on the learning outcomes of phase E class students at MA Zainul Bahar Bondowoso. In the results of scoring and data processing, an increase from pretest to posttest was obtained where all students experienced 100% completeness, followed by the N-Gain test value in this study was 0.82 with a high category, meaning that learning using E-Booklet was able to improve student learning outcomes. In accordance with the opinion (Fakhrudin & Kuswidyanarko, 2020) that optimizing learning outcomes will be obtained if there is learning media and attracts the attention of students.

The e-booklet on the utilization of endophytic fungi isolated from *Phalaenopsis amabilis* roots works better because it integrates real local research results into the teaching materials, thus providing a more contextual and relevant learning experience for students. This approach allows students not only to understand the concept of Kingdom Fungi theoretically, but also to see first-hand how fungi play a role in symbiotic mutualism with orchid plants that are widely known in Indonesia. The use of familiar and high conservation value moon orchid species also increased student curiosity and engagement. In addition, because it is based on hands-on research, this E-booklet presents original data and images that can strengthen visual understanding and science processes, compared to learning media that only take generic examples from textbooks.

From previous research, the results of this study are also relevant to previous research. research conducted by Gusnita, A., S., H., & Anggriyani, R. (2024) E-Booklet can improve learning outcomes and with learning completeness reaching 93%. Research conducted by Aisyatunnisa, R., & Halang, B. (2024) revealed that the development of E-Booklet media was able to increase student interest in learning as evidenced by the increase in learning outcomes by students.

CONCLUSION

The results showed that the development of E-Booklet learning media from P.*amabilis* root fungi for the kingdom of fungi successfully achieved the desired goals. By using the ADDIE development model, this media is considered very feasible and practical. Validation from experts shows that this media has excellent quality in terms of material with a score of 91%, media with a score of 87% and student response with a score of 85% with very feasible and practical criteria. The increase in student learning outcomes was also significant, seen from the average posttest score of 89.60 compared to the pretest of 42.1. The noemality test showed significant results ($p = 0.00 < 0.05$) with an increase in learning effectiveness of 0.82 with a high category based on the N-gain value. These findings have the potential to support the development of the national biology curriculum through the integration of contextual learning media based on local potential. This E-Booklet is in line with the principles of the Merdeka Curriculum because it encourages independent learning, science literacy, and interest in biodiversity. Therefore, similar media is worth adapting as a relevant and interactive additional learning resource in various schools..

RECOMMENDATION

To strengthen these findings, future research is recommended to use an experimental design with a control group so that the comparison of the effectiveness of E-Booklets with other learning methods can be analyzed more comprehensively. In addition, it is important to evaluate the long-term impact of using E-Booklets on students' critical thinking skills and scientific attitudes, given that the material presented is based on local scientific findings. Thus, the development of such media not only supports the improvement of learning outcomes, but

also contributes to the strengthening of science literacy and the utilization of Indonesian biodiversity in biology learning.

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