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Development of E-book Teaching Materials: Overview and Applications of Microbial Biotechnology

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Abstract: Microbial biotechnology is a branch of science that utilizes microorganisms, enzymes, or cellular components to produce products and services in various fields such as food, health, agriculture, and the environment. Advances in modern technology, including genetic engineering, tissue culture, and PCR, have significantly expanded the potential applications of microorganisms, making a basic understanding of the concepts, history, and applications of microbial biotechnology essential for biology students. The development of e-book-based instructional materials provides ease of access, interactivity, and systematic presentation of information to support effective learning in microbial biotechnology. This study aims to produce educational materials in the form of an e-book on the general overview and applications of microbial biotechnology that can be applied to courses in the Biology Education Program (S1) at the Faculty of Teacher Training and Education, Balitar Islamic University, by adapting the Borg and Gall development model. The average validation analysis result was 83% in the valid category, and the average small-group trial result was 82%, categorized as suitable for use as teaching materials.

INTRODUCTION

Biotechnology is a rapidly developing branch of biology in line with advances in science and technology. One important field in biotechnology is microbial biotechnology, which utilizes microorganisms such as bacteria, fungi, and yeast in various aspects of life, ranging from food production, medicine, renewable energy, to environmental management (Velmulugran et al., 2025). The existence of microorganisms that have the ability to produce enzymes, metabolites, and bioactive compounds makes microbial biotechnology a strategic topic that

biology students, especially prospective biology educators, need to understand (Fidiastuti et al., 2024). This understanding is expected to equip students to integrate theory with real practice and prepare them to face the challenges of scientific development in the 21st century.

Although microbial biotechnology is of high urgency, the learning process in higher education still faces various limitations. Based on the results of observations and initial interviews with lecturers teaching the Biotechnology course in the Biology Education Study Program at the Islamic University of Balitar (UNISBA Blitar), it was found that learning still relies on sources from general textbooks, scientific articles, the internet, and practicum modules. As a result, students' understanding of the application of microbial biotechnology is still limited, and some students even have difficulty relating basic concepts to their application in the fields of health, industry, and the environment (Ruiz-gonzález et al., 2025).

To date, there are no specific teaching materials in the form of e-books that provide a systematic, applicable overview and application of microbial biotechnology in line with student needs. E-books have quickly become one of the most popular forms of educational media, especially among university students. E-books can be texts stored in digital format, digitized books, digital reading materials, books stored in computer file format, or electronic files containing words or images that have been given a unique ID (Hashim et al., 2024). Recently, the availability of e-books on various mobile devices has replaced conventional print resources, which are considered expensive to produce and distribute, as well as heavy (Makwanya & Oni, 2019).

The results of the needs analysis also show that most Biology Education students at UNISBA Blitar have not obtained teaching materials that specifically discuss microbial biotechnology in depth. This condition has the potential to cause misconceptions in understanding concepts and weaken students' scientific thinking skills. In fact, students in the digital era need teaching materials that are not only rich in content but also easily accessible, interactive, and in line with the characteristics of modern learning (Aini et al., 2023).

To address this need, the development of e-book-based teaching materials on the general overview and applications of microbial biotechnology is an appropriate alternative solution. E-books are considered relevant because they can be designed with a scientific approach, which emphasizes the integration of students' knowledge, skills, and scientific attitudes. In addition Majid et al. (2019), e-books offer flexibility in presenting material with the support of images, illustrations, and digital references. The main advantages of e-books, according to students' perceptions, are the ability to store many e-books on personal devices, the ease of use of e-books, and the elimination of the need to go to a physical library. This can make it easier for students to understand the concepts of microbial biotechnology in context (Andriani et al., 2025).

Based on the above description, it is necessary to conduct development research focused on "Development of E-book Teaching Materials on General Overview and Applications of Microbial Biotechnology for Biology Education Students at Balitar Islamic University." This e-book is expected to be an applicable, easy-to-understand learning resource that can improve the quality of biotechnology learning, so that students have a better understanding of the basic principles and applications of microbial biotechnology in real life.

RESEARCH METHODS

This research is a type of research and development based on laboratory research results. Data obtained from laboratory research is used as the basis for developing teaching materials. The process of developing e-book-based teaching materials uses the Hannafin & Peck (1987) model, which consists of three main stages, namely: (1) Assessment (needs analysis), (2) Design, and (3) Development & Implementation (Sari et al., 2017). Each stage in this model is always followed by evaluation and revision activities to ensure the quality of the developed product.

Data analysis in this development study was conducted using two approaches, namely qualitative descriptive and quantitative descriptive (Ayu et al., 2021). Qualitative analysis was used to process data in the form of responses, comments, and suggestions for improvement from validators, both subject matter

experts and media experts, as well as the results of limited trials in small groups. The data was grouped to obtain relevant input for product improvement. Meanwhile, quantitative analysis was used to process the validation scores using the assessment instruments that had been developed.

The validity percentage of e-books is calculated using the formula:

$$P = \frac{\sum x}{\sum xi}$$

Description:
P = percentage of validity
∑x = total score obtained
∑xi = maximum possible score
100% = constant

The percentage calculation results are then interpreted with reference to the validity criteria (Sumbawati et al., 2024) As shown in Table 1 below:

Table 1. Criteria for Interpreting Textbook Validation Assessments

Score Achievement	Validity criteria	Description
25%-40%	Not valid	Not allowed to be used
41%-55%	Less valid	Not allowed to be used
56%-70%	Quite valid	Can be used after major revisions
71%-85%	Valid	Can be used after minor revisions
86%-100%	Very valid	Can be used without revisions

Thus, the validation results obtained will serve as the basis for determining product quality and the revisions that must be made so that the e-book-based teaching materials developed are truly suitable for use in learning.

RESULTS AND DISCUSSION

The development of teaching materials in the form of an e-book entitled Overview and Applications of Microbial Biotechnology has undergone a series of validation stages by subject matter experts, media experts, and readability tests on a small group of students. This process was carried out to ensure the suitability of the content, presentation, language, and technical aspects of the e-book to meet learning needs (Baltu & Irawan, 2025).

The results of validation by subject matter experts show that this e-book has achieved an average percentage of 82.8%. In terms of content suitability, the score obtained was 84% in the valid category. The language suitability aspect also received a high score of 80% (valid), indicating that the language used is clear and communicative. However, in terms of presentation, the score obtained was 84.4%, so it is still categorized as quite valid with minor revisions. This shows that the presentation of the material still needs improvement in terms of display consistency, visual clarity, and content layout (Fitri et al., 2024).

Validation from media development experts obtained an average percentage of 83.1%, with all aspects, including the size of the e-book, cover design, and book content design, falling into the valid category. The size aspect obtained the highest score of 82%, indicating that the e-book format is suitable for use as digital teaching material. The cover design received a score of 84.3%, while the e-book content design received 83%. However, several notes were given regarding typographic consistency, clarity of illustrations, and the relevance of images to the content. Consistency in the use of design elements such as color, font, and style helps strengthen the unity and identity of the product (Setiawan & Amayati, 2025).

The readability test results by 20 students in a small group showed an average percentage of 82%. This percentage is considered valid and does not require major revisions. The content aspect received the highest score of 84%, followed by the graphics aspect with 83%, language with 84.06%, and presentation with 79%. These results indicate that the e-book is quite easy to understand, interesting, and relevant to students' learning needs. E-books also make it easier for educators to create a different and exciting learning atmosphere for students (Sihombing et al., 2024).

In addition to quantitative data, qualitative responses from validators and students provided important input. Some of the comments are shown in Table 2 below:

Table 2. Comparison Table of Expert Validation Results and Small Group Testing

Validator	Average Score (%)	Strengths	Weaknesses
Expert	83%	1. The material is relevant to basic competencies and sufficiently comprehensive. 2. The bibliography is adequate. 3. The layout, typography, and illustrations are generally neat. 4. The presentation of content and language meets academic standards.	1. Some scientific terms are still complicated. 2. There are repetitions of theory that could be condensed. 3. The illustrations are not entirely representative. 4. The color contrast in some sections reduces readability. 5. The difference between the font used for the title and the content is not clear enough.
Small Group	82%	1. The book is easy for lay readers to understand. 2. The text and images are generally consistent. 3. The exercises help with comprehension. 4. The layout is considered attractive and easy to read	1. Some sentences are too long. 2. Some illustrations are irrelevant. 3. The background color of certain chapters is too dark. 4. The number of practice questions is limited. 5. The font size is a bit small. 6. Blank pages should be used for summaries/key points.

The validation results from experts show an average score of 83%, which falls into the excellent category. In general, the material is considered relevant to basic competencies, the content is quite complete, and the layout and illustrations meet academic standards. However, there are still some weaknesses that need to be addressed, such as the use of overly complicated scientific terms, repetition of material, and color contrast and typography that need to be improved for optimal readability. New writing styles, disposition, and interaction with content may also occur, and new curriculum guidelines for undergraduate programs should be considered, as several factors may necessitate new adaptations and updates to the e-book. It should be noted that the subjective observations of experts were taken into account and mostly referred to the e-book authors to convey the feedback

collected and enable them to improve the product through a validation process (Lima et al., 2024).

Meanwhile, the small group trial obtained an average score of 82%, which is also in the very good category. Respondents stated that the book was easy to understand, the text and images were well aligned, and the exercises helped improve their understanding. Students associated e-books primarily as a new source of information (Nahotko & Deja, 2024). Although the e-book was considered easy to use, this aspect did not influence students' attitudes and intentions to use it as much as its perceived usefulness. However, several areas for improvement were identified, including overly long sentences, irrelevant illustrations, overly dark background colors, a limited number of exercises, and a font size that was a bit small. It was also suggested that some blank pages be used for summaries or key points. Future studies may explore ways to improve and adjust these design features to suit the needs of various user groups (Yang et al., 2022). Overall, this book is worth using and is categorized as very good, both from expert and user assessments, with some minor revisions to the content, visual appearance, and presentation for optimal results.

The final product, in the form of an e-book, can not only be used as a source of literature for Biotechnology courses in the Biology Education Study Program, but also has the potential to be used more widely in various relevant study programs. Research by Oyaid & Alshaya (2019) shows that the discussion group concluded that almost all students found the use of e-books for educational purposes very useful, because they believe e-books are cheaper, portable, and easily accessible from anywhere and at any time. Some participants may experience problems in use, such as the absence of copy-paste options, etc.; however, the majority of them plan to use e-books in the future if the characteristics and features of the e-book are the same as this book. With minor revisions according to the validator and student input, this e-book is expected to support interactive, contextual, and applicable learning in line with current developments in microbial biotechnology. Currently, interactive e-books are the most effective type of e-book compared to other types, considering that this type of e-book has been tested on users of various ages and

educational backgrounds, with different subjects, and in different implementation locations (Suriani, 2023). The majority of students are introduced to e-books by their lecturers. The main factors influencing the adoption of e-books are performance expectations, effort, and supporting conditions, while social and gender influences also play a role. The practical implications for universities and publishers are to improve e-book features according to student needs, provide reliable internet access, and strengthen support from lecturers and institutions (Okocha, 2021).

CONCLUSIONS AND RECOMMENDATIONS

The validation results show that the book received an average score of 83% from experts and 82% from a small group test, placing it in the excellent category and declaring it suitable for use. However, several aspects still need to be improved to optimize its quality. Recommendations for further research include improving the content and language, namely simplifying scientific terms, correcting spelling and grammar, and condensing repetitive material. Furthermore, in terms of illustrations and media design, the quality and relevance of images need to be improved, the color contrast needs to be corrected, and the typography and font size need to be made more consistent. Finally, in terms of presentation and readability, it is recommended to increase the number and variety of exercises, utilize blank pages for summaries, and shorten sentences that are too long. With gradual improvements according to these priorities, the book will become more communicative, interesting, and easier for users to understand.

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