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E-Encyclopedia for Biology Education: Design, Development, and Evaluation of an Innovative Learning Resource

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Abstract: Understanding laboratory equipment is a fundamental competency in science education. However, students often face difficulties in mastering laboratory tools due to the lack of practical and reliable learning resources. Dependence on invalid sources negatively affects the quality of practicum and research. This study aims to develop and evaluate the feasibility of a digital encyclopedia on laboratory equipment as a learning resource to enhance the effectiveness of science learning. The research employed a Research and Development (R&D) approach using the 4D model: Define, Design, Develop, and Disseminate. The Define stage involved needs analysis through surveys and interviews, curriculum analysis, student characteristics analysis, and formulation of learning objectives. The Design stage focused on creating a product prototype. The product was validated by four experts (a subject matter expert, a media expert, a language expert, and an instructional design expert). Practicality testing involved 28 students and 4 lecturers from the Biology Education study program. The validation results showed scores of 93% for language, 93.2% for content, and 95% for media, indicating that the digital encyclopedia is very feasible for use. Practicality tests resulted in a score of 96.2% from students and 88.33% from lecturers, indicating that the product is very practical, engaging, and effective in supporting independent learning. The final results conclude that the digital encyclopedia is both valid and practical as a learning resource. The study recommends further development with broader content coverage and the integration of Augmented Reality (AR) technology to enhance interactivity.

INTRODUCTION

In the digital era, education plays a vital role in developing globally competent individuals and enhancing the quality of education at both national and international levels (Nenohai et al., 2022). To achieve this, educators need to possess strong digital literacy, understand the needs of their students, and be capable of selecting and integrating educational technologies into the curriculum in a comprehensive manner (Rizki et al., 2020). Digital platforms should not merely serve as supplementary tools, but rather as integral parts of the learning process that foster active engagement and optimal learning outcomes (Selaturrohmi & Haikal, 2024). regular evaluations and the utilization of technology for international collaboration are also crucial aspects. The success of countries

like Singapore, Estonia, and Finland demonstrates that synergy between government policy, teacher competence, and technological support is key to delivering effective digital education (Norgard & Holflod, 2024). However, digital innovation often faces challenges from traditional values such as conventional teaching methods and resistance to change (Alim & Subali, 2020). Therefore, an adaptive and inclusive approach is needed one that builds upon traditional values as the foundation for innovation. The balance between discipline, face-to-face interaction, and flexibility and accessibility of digital learning will help create a sustainable and comprehensive educational ecosystem (Wekke & Astuti, 2017). Modernization can support the learning process towards a better.

Education in the Society 5.0 era is increasingly integrated with technology to create learning that is flexible, efficient, and relevant to contemporary needs (Yasir et al., 2022; Mansyur et al., 2023). In this context, the concept of an adaptive curriculum becomes essential for educators to understand both its meaning and practical implementation. An adaptive curriculum is a learning approach designed to tailor content, methods, and media to the needs, potential, and characteristics of individual students. This aligns with the essence of Society 5.0, where the collaboration between humans and technology is leveraged to enhance the quality of education and equip younger generations with 21st-century skills (Carayannis & Morawska-Jancelewicz, 2022). Through adaptive curricula, educators can effectively integrate technology to foster personalized, contextual, and innovative learning. Universities and industries also play a significant role in supporting the development of curricula that are responsive to global dynamics, thereby producing innovators who are not only intellectually capable but also possess strong information literacy. Therefore, the adaptive curriculum serves as a crucial foundation for shaping an educational ecosystem that can sustainably address the challenges and opportunities of the digital era (Hafizah, 2023).

The primary goal of biology education is to develop an understanding of life concepts, foster scientific curiosity, and enhance critical thinking and problem-solving skills through scientific approaches (Shofatun et al., 2024). The learning process is directed toward increasing learning effectiveness through nature exploration and laboratory practice. Biology is not only about conveying information or concepts, but also emphasizes self-discovery and understanding of the surrounding environment . Learning is carried out through various active methods, such as direct observation, laboratory experiments, and bioprocess modeling, all of which play an essential role in sharpening students' scientific skills. Therefore, proper understanding and use of biological laboratory equipment are crucial to support practical activities that are safe, efficient, and meaningful, as well as to help students directly connect theory with practice (Istikomayanti et al., 2024).

Students in the field of science, including Biology, are required to master fundamental knowledge of laboratory equipment to support efficient and effective research (Lestari et al., 2023). Understanding the functions and operation of tools such as microscopes, autoclaves, hotplates, and various other laboratory instruments is essential for conducting practicals and biological research. Microscopes assist in observing the structure of microorganisms and tissues, autoclaves are used for sterilizing equipment and culture media, while hotplates are useful for controlled heating during experiments.

Proficiency in using these tools not only enhances the effectiveness of practical sessions but also supports laboratory safety (Idris et al., 2022). Independent learning outside of lecture hours is an effective method to improve students' academic skills. Through this approach, changes are expected in students' knowledge, attitudes, and skills, thereby supporting comprehensive mastery of the material and the full application of the scientific method (Hidayat et al., 2021).

To support self-directed learning, students need access to user-friendly and technologically relevant sources of information. One reliable alternative learning source is a digital encyclopedia (Tatnall, 2020; Maryani & Dewanti, 2024; Audriansyah et al., 2022; Cahyanti et al., 2021), particularly for understanding biology laboratory equipment. Digital encyclopedias offer several advantages, as they present information in a structured format, are easily accessible, interactive, and supported by visual and multimedia elements that help clarify concepts (Sarinah et al., 2024). Images of laboratory equipment in digital encyclopedias enable students to visually identify the shapes, components, and functions of tools, while descriptive information on usage and operational procedures helps them understand proper practices (Ramanda et al., 2024). This is crucial for fostering laboratory equipment literacy and enhancing students' technical skills before engaging in practical lab work. In the context of Biology courses at UIN Sulthan Thaha Saifuddin Jambi, students' understanding of laboratory equipment remains relatively low. Unfortunately, there is still a lack of comprehensive and easily understandable learning resources, especially those that include images, functions, and usage guides. As a result, students often turn to websites of questionable reliability, which can lead to misconceptions and unsafe laboratory practices that do not comply with safety standards (Azizah et al., 2023).

Accurate and easily applicable learning resources have a significant positive impact on the learning process, as they support the achievement of optimal learning outcomes. Accuracy or validity refers to the extent to which an instrument or product aligns appropriately and precisely with its intended purpose (Apriansyah et al., 2024) . Internet-based products, in this context, can ensure that the delivered materials are aligned with learning objectives and students' needs. This validity includes content validity (the alignment of material with competencies and indicators), construct validity (the ability of the instrument to measure what it is intended to measure), and language validity (clarity and appropriateness of language use), all of which contribute to the creation of an effective learning process (Ferdian et al., 2025).

Based on the results of interviews with lecturers, it was revealed that students are expected to study independently at home. However, they face difficulties in finding reliable learning resources, both from books and the internet. Therefore, the lecturers suggested the creation of a digital encyclopedia to help students meet graduation standards. Observations also showed that although students pay attention to lecturers' explanations during class, they still do not understand the names, functions, and how to use laboratory equipment. All respondents agreed that a digital encyclopedia is highly needed to support the learning process. This digital encyclopedia innovation serves as a new solution to students' difficulties in finding credible references. Lecturers emphasized that existing teaching materials are not sufficient to support independent learning and achieving

graduation standards. In addition, the ongoing difficulties students face in understanding laboratory equipment indicate the need for more effective materials. The respondents' agreement highlights that the development of a digital encyclopedia is a timely and appropriate solution to meet these needs.

METHOD

The type of research used in this study is Research and Development (R&D), which is designed to produce a digital encyclopedia of biology laboratory tools as a learning resource for students This research is focused on biology students. It employs a mixed-method approach, combining qualitative and quantitative methods to obtain more comprehensive results. The qualitative approach can strengthen the quantitative data, and vice versa, while the quantitative approach is used to provide an objective general overview.

The research and development process generally follows a specific cycle aimed at producing a product that meets user needs. The steps involved include needs analysis, initial product testing to identify weaknesses, product revision based on test results, and subsequent testing to refine the product. This study adopts the 4D development model, which serves as a framework for designing learning tools. This model, developed by S. Thagarajan, Dorothy S. Semmel, and Melvyn I. Semmel, consists of four main stages: define, design, develop, and disseminate (Ramanda et al., 2024).

Specifically, the implementation of the 4D model in this study began with the define stage, which involved identifying and analyzing the curriculum to determine the competencies that needed to be achieved, analyzing students' problems, assessing their needs and characteristics, and analyzing lecturers' needs through interviews and curriculum analysis. In the design stage, the researcher developed an initial prototype of the learning product, such as a digital encyclopedia adapted to students' characteristics and learning objectives. During the develop stage, the prototype was tested on a limited scale to gather feedback from users (lecturers and students), followed by revisions to address any identified shortcomings. Finally, at the dissemination stage, the developed product is distributed through the university's Learning Management System (LMS) so that it is expected to become an educational solution in the future. However, this study was limited to trial implementation involving biology lecturers and students (Sari et al., 2023).

The trial process was conducted on a limited scale, involving two groups of students seven students in a small group and twenty-one students in a large group, with implementation carried out at different times. The types of data collected in this study include quantitative and qualitative data where both data will support each other and provide better and more comprehensive research results. Researchers feel that combining both research data will produce research that can be universalized for all learning, especially in the field of biology education. Quantitative data were obtained from student questionnaire responses, which covered aspects of product validity as well as practical feedback from both lecturers and students. Meanwhile, qualitative data were collected through in-depth interviews with students and course lecturers involved in this study. As

for the assessment formulation, both the validity of the score and the practicality of the product created can be seen in Figure 1.

$$\text{Validity Score} = \frac{Total\ Score\ Obtained}{Maximum\ Score} \times 100\%$$

$$\text{Practicality Score} = \frac{Total\ Score\ Obtained}{Maximum\ Score} \times 100\%$$

Figure 1. validity of the score and the practicality of the product

The assessment of practicality both for individual dimensions and the overall construct was conducted using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) (Kagerbauer & Magdolen, 2024; Vosniadou et al., 2020). The Likert scale was selected due to its well-documented reliability in measuring respondent attitudes (Boone & Boone, 2012). To enhance interpretability, numerical responses were categorized into qualitative tiers (1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good). This classification adheres to methodological guidelines for translating statistical data into actionable insights (Jamieson, 2004). The quantitative-to-qualitative conversion also strengthens practical applicability, ensuring clarity for stakeholders (Cohen, 2018; Saunders, Lewis, & Thornhill, 2019).

Table 1. Criteria for Assessing the Validity of the Digital Encyclopedia

Score	Criteria
85% - 100%	Very valid
70% - 84,9%	Valid
55% - 69,9%	Fairly valid
25% - 54,9%	Not valid

Learning media is considered to have a satisfactory level of validity if the average score falls within the 'valid' category. If the score is below this threshold, the media should be revised based on input from experts (validators) (Rosdiana et al., 2019; Vuztasari et al., 2023). Following revision, the media is subjected to revalidation and the results are analyzed once again. This iterative process continues until the media achieves the 'valid' category. As for seeing the Criteria for Assessing the Level of Practicality of the Digital Encyclopedia that the researcher has created, it can be seen in Table 2.

Table 2. Assessment Criteria for the Practicality Level of the Digital Encyclopedia

Score	Criteria
85% - 100%	Very Practical
70% - 84,9%	Practical
55% - 69,9%	Moderately Practical
25% - 54,9%	Not Practical

To determine whether the teaching material in the form of a digital practical encyclopedia is practical or not, the final results can be examined. If the research results show that students give a positive response and consider the teaching materials practical, then the digital encyclopedia can be said to be practical and worthy of being used as the

best learning resource for today. The learning process must always be innovated (Ananta & Kurniawan, 2023; Hapke et al., 2020) so that learning will always be felt interesting and enjoyable (Ayua et al., 2024; Zheng et al., 2021).

RESULT AND DISCUSSION

The research that has been conducted provides a very valuable picture and information especially in the world of learning biology education for today. The products produced through this process have been evaluated by experts to ensure their quality and suitability as learning media. Based on these findings, it is recommended that further research be conducted on digital encyclopedias incorporating augmented reality (AR) technology (Done et al., n.d.; Johnston & Hayes, 2011). The research results obtained during the current research process and also the findings that researchers obtained, especially the stages involved in the development process, are explained in more detail and comprehensively.

Define

The stage of designing a product is the initial and very important stage in a research and development process, where this stage is the initial step that must be taken before designing learning resources that are truly in accordance with the criteria and learning rules carried out in this study. At this stage, several important processes need to be completed as a foundation for the development of further learning resources (Kim, 2014; Puccio et al., 2005). The part of the initial stage concept can be explained and described in more detail and completely.

Curriculum Analysis

The curriculum used at UIN Sulthan Thaha Saifuddin Jambi is based on the Merdeka Curriculum, which is the national curriculum. One of the mandatory courses that must be taken by second-semester students of the Biology Education program is the Biological Laboratory Knowledge course. In its development, the curriculum analysis is conducted by aligning the Course Learning Outcomes (CLOs) and Learning Indicators outlined in the Semester Learning Plan (SLP). The main focus of this research is on the learning in the fifth week, particularly on CLO-5, which covers various types of biological laboratory equipment, and CLO-6, which explains the procedures for operating these tools. The details of the Course Learning Outcomes and Learning Indicators for this course are systematically adjusted according to the established SLP.

This research directly contributes to curriculum development through the design and testing of relevant and contextual learning products, particularly in supporting the achievement of Course Learning Outcomes (CLOs). By developing more practical and student-centered learning media or tools, the results of this study are expected to enhance the effectiveness of the learning process and serve as a reference for lecturers in improving and innovating the Course Syllabus (SLP) or teaching materials used in the Biological Laboratory Knowledge course. Thus, this research not only impacts the improvement of

learning quality but also strengthens the alignment between curricular objectives and teaching practices in the field.

Student Problem Analysis

To identify the challenges faced by students during the Biology Laboratory Knowledge course, an analysis was conducted on various issues encountered throughout the learning process. This analysis was carried out by distributing questionnaires to students who had completed the course. The questionnaires were disseminated online via the Google Form platform, allowing for practical and efficient data collection. The obtained data were then used to identify the obstacles experienced by students during the learning activities (Siraj & Milfayetti, 2017; Weng et al., 2023).

Based on the data, the majority of students, namely 90%, pay close attention to and actively engage with the lecture material. However, the students' level of understanding of laboratory equipment still varies. According to interviews, this variation is generally attributed to a disconnect between the theoretical concepts delivered in class and the practical experiences in the laboratory during previous courses. Furthermore, the lack of visual introduction to laboratory tools contributes to misunderstandings regarding their use. Students' comprehension can be enhanced by providing learning resources for independent study at home as well as during classroom instruction (Azizah & Supriana, 2023; Bahrudin & Yogihati, 2022; Keleszade et al., 2018). Only 55% of students reported having a good understanding of biological laboratory equipment. Interestingly, all students agreed that they strongly require additional learning materials to deepen their understanding of laboratory tools and their optimal usage. In line with this research, students expressed interest in using digital encyclopedia learning resources focused on biological laboratory equipment, featuring visual illustrations and comprehensive explanations, including operational procedures aligned with the equipment available in the biology laboratory. This e-encyclopedia learning resource can facilitate and streamline students' reference searches during study. Additionally, course instructors can utilize this digital encyclopedia as a strategic reference tool to guide practical sessions.

Analysis of Student Needs and Characteristics

To identify the needs and characteristics of students in the learning process, a study was conducted by distributing questionnaires online through the Google Forms platform. The collected data were analyzed to gain a deeper understanding of how students learn and what they require to support this process. The results of this analysis serve as a crucial foundation for designing and developing a digital encyclopedia tailored to students' preferences, learning styles, and actual needs.

The majority of students most frequently use smartphones during learning activities, both at home and in the classroom, with a usage rate of 95%. Currently, smartphone use in learning has become an essential facility for students to seek information related to learning materials. Students predominantly rely on smartphones to access e-journals, educational videos, and online discussion forums, which significantly enhance their self-directed learning abilities. Furthermore, the use of smartphones to explore learning materials tends

to correlate with higher digital literacy in completing assignments. Smartphones also encourage students to be more proactive in independent learning (Hidayat & Susilawati, 2022). In the learning process involving biological laboratory equipment, most students reported being able to maintain focus, with a percentage of 85%, as smartphones provide easy access to information. This supports students in seeking references and allows them to remain engaged with their smartphones during independent study at home (Amalakanti et al., 2024). However, during independent learning activities, students tend to use the internet as their primary source of information. Unfortunately, many of them rely on references that lack credibility and validity. Given this situation, the majority of students expressed their support for the development of valid and reliable learning resources, such as digital encyclopedias containing comprehensive information about biological laboratory equipment, including names, images, functions, and usage instructions.

Lecturer Needs Analysis

The needs analysis of lecturers was conducted through interviews with the lecturers responsible for the related courses. This analysis is carried out so that the research results can provide an accurate picture in accordance with the reality in the field (Badri et al., 2016; Jum et al., 2024). The purpose of this analysis was to explore and understand the needs from both the lecturers' and students' perspectives, so that the developed product could be tailored to meet their expectations and requirements. The results of these interviews provided an in-depth overview of the aspects that need to be considered in the development of learning products, particularly from the viewpoint of the course lecturers. Based on the interviews with the course lecturers, it was found that students tend to seek independent learning resources because the materials provided by the lecturers, such as PowerPoint presentations, are still limited. They require clearer and more valid sources, such as books or journals, especially to understand biology laboratory tools. Clear reference sources can provide additional information that is useful in lecture activities (Akhtar, 2021; Chhabra et al., 2022). Therefore, the course lecturers agreed that the development of valid and practical learning resources is highly necessary to support the learning process and to meet the minimum course passing criteria.

Design

In the design phase, the development of the learning resource design and the instruments to be used in the development process are carried out. This learning resource design is formulated based on the results of the needs analysis and the predetermined learning sequence.

Formulation of the Design for a Digital Encyclopedia

The compilation of this digital encyclopedia encompasses several essential elements, including a cover featuring the encyclopedia's title and the author's name, a foreword, a table of contents, explanatory material, photographs of biology laboratory equipment, and a bibliography. The development process began with the planning stage, followed by a series of steps: first, designing all elements using the Canva application; second, after the design was completed, importing and further editing all elements in Canva, then converting

the file into PDF format to create a Flipbook; and finally, in the last stage, uploading the finished PDF file to the Fliphtml5 website for online access. This research process provides a product that can be used by students in learning, where the Digital Encyclopedia Cover can be seen in Figure 1.

Figure 1. Digital Encyclopedia Cover

The main part of an e-module that has been created is the initial description such as the part of Figure 1 showing the initial cover page of the digital encyclopedia learning resource containing the title of the digital encyclopedia and the author's name. so that the identity of the module used becomes clear and is a new product in the biology learning process that is able to provide breakthroughs and support in learning.

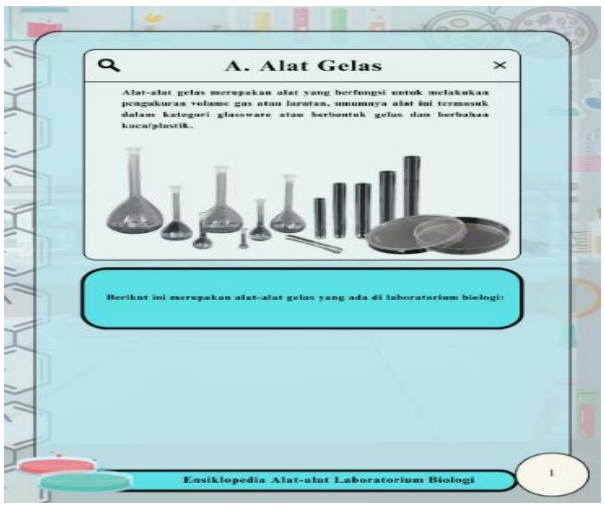

Figure 2. Introduction to Glassware in the Digital Encyclopedia

The digital encyclopedia learning resource is systematically divided into two main categories: (1) glassware and (2) non-glassware laboratory materials. As depicted in Figure 1, the glassware section provides detailed explanations of each instrument's definition, classification, and practical functions in scientific settings. This comprehensive resource documents 38 distinct types of glassware, with particular emphasis on equipment commonly used in biological laboratories, including beakers, Erlenmeyer flasks, test tubes, and graduated cylinders (Barker, 2019; Madigan, Bender,

Buckley, Sattley, & Stahl, 2021). The integration of high-quality visual aids with concise textual descriptions enhances its effectiveness as an educational tool for both students and laboratory professionals.

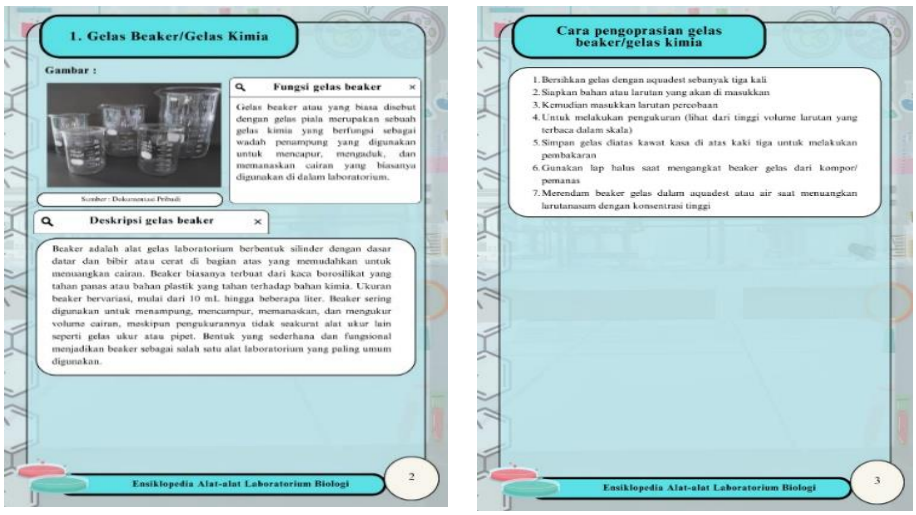

Figure 3. Content of the Digital Encyclopedia: Glassware Materials

The figure above illustrates part of the digital encyclopedia's content, which consists of various types of glassware commonly found in biology laboratories. Each item includes the name of the tool, a picture or photo, its function, a description, and operating instructions. The product is given a detailed and clear name so that students can be helped in carrying out learning activities, especially if the object given is new to them. This label or reading becomes a tool and marker for students to make it easier for them in the learning process. The convenience provided is believed to be able to provide encouragement and enthusiasm for students to become better and quality learners and at the same time encourage students to grow their interest in learning independently. The interest in learning that arises directly from students can be a trigger and motivator for students to enjoy and be enthusiastic about learning.

Figure 4. Introduction to Non-Glass Equipment in the Digital Encyclopedia

The image above presents an introduction to non-glass equipment, including definitions and functions of these tools. The non-glass equipment consists of items such as autoclaves, microscopes, and others. In total, there are 65 non-glass instruments frequently used during biology practical sessions.

Figure 5. Contents of the Non-Glass Equipment Section in the Digital Encyclopedia

The image above shows the digital encyclopedia's section on non-glass equipment, which includes the following components: the name of the equipment, an image of the equipment, its function, a description, operating instructions, and the structural parts of the non-glass tools themselves.With this comprehensive section, users can gain a deeper understanding of various non-glass equipment and their applications. By providing detailed information on each component, the digital encyclopedia enables users to effectively utilize non-glass equipment and make informed decisions. This section serves as a valuable resource for individuals seeking to expand their knowledge on non-glass equipment and their uses. The final product produced is believed to be able to provide additional encouragement and motivation to students in learning, where the product can be seen in Figure 6. Final Page of the Digital Encyclopedia

Figure 6. Final Page of the Digital Encyclopedia

On the last page of the digital encyclopedia, the author provides motivational words related to biology laboratory equipment. This provision is expected to be able to increase students' enthusiasm in carrying out and using the learning process. Every educator must realize that students are users of learning, so students must be encouraged and always motivated to be able to realize the importance of knowledge for their future.

Design of Assessment Instruments

The instruments in this study function as evaluation tools containing a series of statements addressed to experts, lecturers, and students in order to assess the feasibility, practicality, and effectiveness of the developed productIn order to develop a digital encyclopedia, several assessment instruments were designed involving linguists, content experts, and media experts. The experts were selected according to the fields needed in this study, this was attempted to provide better answers and be accountable for the results of the research. Additionally, evaluations were also conducted by lecturers and students. The instruments provided to the experts focused on assessing the feasibility aspects of the compiled learning resources, while the questionnaires for lecturers and students were used to evaluate the level of practicality in its usage. All questionnaires employed in this study underwent a validation process by experts and were declared valid with a 100% validity rate, thus requiring no further revisions.

Development

The development stage has the primary objective of producing learning resources that meet the criteria of validity and practicality. During this stage, a series of systematic processes are carried out to ensure that the materials developed are not only theoretically strong but also effectively applied in practice. The strength of the learning process certainly cannot be separated from the theory, how to apply learning and also the media used in the learning process itself. However, in this study, the researcher focused on creating a good media that can be easily used by teachers in learning while being able to encourage students' enthusiasm and motivation in learning.The development process includes the following steps.

Validity of Learning Resources

The validity of a product refers to the degree of accuracy and legitimacy, indicating the extent to which the product is suitable for use. The assessment of this suitability is typically carried out by experts who have competence in the relevant fields. In this context, the validation process for the learning resource, in the form of a digital encyclopedia, is conducted by three experts: a language specialist, a design expert, and a subject matter expert. Each expert provides an evaluation based on their respective expertise to ensure that the developed learning resource meets quality standards and can be effectively utilized in the learning process. The expertise of the validator will determine the accuracy of an instrument and also the research results.The validation of the digital encyclopedia learning resource was carried out by four experts, all lecturers from UIN Sulthan Thaha Saifuddin Jambi, with the resulting percentage scores as Tabel 3.

Table 3. Results of Digital Encyclopedia Validation

Criteria	Language Expert	Content Expert	Design Expert
Total of Indicators	14	22	26
Total Score	52	82	99
Total Percentage	93%	93,2%	95%
Category	Very Valid	Very Valid	Very Valid

Based on the evaluations conducted by experts, the digital encyclopedia was found to be highly valid. The language expert gave a score of 93%, the content expert rated it 93.2%, and the design expert assigned a score of 95%. The language used in the digital encyclopedia is categorized as highly valid in terms of readability, linguistic logic, and conformity with language rules and images. The contents of the digital encyclopedia are considered very valid in terms of material relevance, material validity, ability to arouse curiosity, presentation components, and completeness of presentation. The results obtained in this development process should be the right indicator for all researchers in the field of education, especially biology learning, how learning products can really attract and improve the quality of biology learning (Chin & Chia, 2004; Machado et al., 2015; Nofriadi & Yestin, 2022). Lastly, the media/design aspect is categorized as highly valid with respect to the size of the digital encyclopedia learning resource, cover design and layout, cover typography (font choice and readability), illustrations in digital encyclopedias, and complete presentations become teaching materials that can provide encouragement to students to participate more in their learning.

The media that has been created will make students motivated to be better and increase student attention in every learning process that is carried out. Several stages in the product development process are maintained and arranged according to the planned research stages, this is used so that the research results can be credible and accountable. The rules of the media that are developed are also made as much as possible so that they are easier to use by users, effective and also efficient (Marwinda et al., 2024; Pahrudin et al., 2019). The research process carried out after the validation stage, the digital encyclopedia continues to the trial stage to see the impact of better and deeper research. where the trial process will be carried out with small group and large group stages so that the data produced in the small group trial can be a reference for conducting experiments on large groups, so that the results will be truly qualified and able to provide a more comprehensive picture of the research results.

Practicality of Learning Resources

To determine the practicality level of a learning resource, an evaluation was conducted using a questionnaire distributed to lecturers and students. This assessment aims to obtain direct feedback from users regarding ease of use and usability of learning resources. The resulting feedback has many meanings, one of which is that it can provide input to teachers to make improvements to the media they create in the future and students will also easily understand the media as a support for their learning process. Students and lecturers must always work together and provide input to each other to create quality learning. In the initial phase, the questionnaire was disseminated and piloted among

lecturers and students. In the early stages, questionnaires were distributed and tested to lecturers and students.

This trial emphasizes the need for habituation to correspondents in implementing or controlling the learning process so that it runs optimally. Each trial correspondent is given the same treatment and in accordance with the rules that have been determined in the module that has been developed. The treatment given is in accordance with the rules and provisions in the module and will be seen how the feasibility and also the weaknesses in the research process in small groups so that the research results can be used for improvement in large group research.The learning process can be carried out as an initial introduction process of what should be used and understood in using the media. Habituation will be a very important and valuable basic ability for research correspondents and researchers to see the advantages and disadvantages of the products made. As for seeing the results of the Digital Encyclopedia Practicality Assessment by Lecturers that have been carried out during the research process, this can be seen in Table 4.

Table 4. Practicality Assessment Results of the Digital Encyclopedia by Lecturers

Indicators	Average Score
Relevance and Accuracy of the Material	
The learning material is in accordance with the Course Learning Outcomes (CLO).	4
The learning material is in line with the development of knowledge.	4
The language used in the learning material follows the Enhanced Spelling System.	4
The concepts and definitions in the learning material are accurate.	3
The images or illustrations are complete.	3
The learning material is consistent with the facts.	3
The data used is aligned with reality.	4
The images or illustrations are accurate.	4
The depth of the learning material is appropriate.	3
Technical Quality	
The images presented are relevant to the material.	4
The images presented are clear.	3
There are captions for the images presented in the learning material.	4
The images presented are engaging.	3
The text in the learning material is easy to read.	3
The content in the learning material is well-organized.	4
Total Score Obtained	53
Total Percentage	88,33%
Category	Very Practical

Based on the practicality assessment conducted by four course lecturers, the digital encyclopedia received a score of 88.33%, which falls into the "very practical" category. This result was based on the clarity and attractiveness of the visuals, the accuracy and reliability of the references, as well as the ease of use. The research process also conducted a direct trial to the correspondent, namely to students, although on a small scale, this was used as one of the researcher's efforts to try to find and provide clear answers and initial analysis of how the contribution of the teaching media that had been made, so that the resulting product was not only stated as good by the validator but also proven to be good

when tested directly to students. The Results of the Digital Encyclopedia Assessment from Small and Large Group Trials (Students) can be seen in Table 5.

Table 5. Digital Encyclopedia Assessment Results from Small and Large Group Trials (Students)

Indicators	Percentage	
	Small Group	**Large Group**
Material Relevance		
The explanation of the material in this learning resource uses sentences that make it easy for me to understand.	100%	96,42%
The illustrations of biological laboratory equipment presented in this digital encyclopedia correspond to those available in the biology laboratory at UIN STS Jambi.	100%	97,61%
I feel comfortable asking questions and expressing the problems I encounter to the lecturer after using this digital encyclopedia.	100%	89,28%
Interest		
I am very enthusiastic about learning independently about laboratory tools using this learning resource	100%	90,47%
By using this learning resource, I have become more interested in learning Biology.	92,85%	94,04%
The presence of images of laboratory tools makes it easier for me to perform practical work in the laboratory.	96,42%	100%
Material Accuracy		
I understand the explanation of the material in this learning resource because it is clear and easy to comprehend.	100%	95,23%
The combination of images makes it easier for me to identify types of biology laboratory tools.	100%	97,61%
I am able to operate biological laboratory equipment after reading, practicing, and understanding the content of this digital encyclopedia.	100%	91,66%
Technical Quality		
I find the texts in this digital encyclopedia easy to read and comprehend.	96,42%	95,23%
I am interested in this digital encyclopedia because the illustrations are relevant to the material and the language used is easy to understand.	96,42%	90,47%
The descriptions (including the names, functions, and usage instructions) accompanying the illustrations in this digital encyclopedia help me to easily recall biological laboratory equipment.	100%	90,47%
Total Percentage Obtained	1.182,11%	1974,95%
Average	98,51%	94,04%
Category	Very Practical	Very Practical

The research process that has been carried out for a long time and by fulfilling all the criteria and limitations of the development research has obtained positive results for researchers, especially in the biology learning process. From some data also provide good and positive indications for example, Based on the results of the practicality test involving twenty-eight students, the digital encyclopedia scored 98.51% in the small group test. The large group test also showed a very high level of practicality, with a score of 94.04%. This assessment is based on several factors, including the clarity and accessibility of the language, the quality and neatness of the colored illustrations, the accuracy and credibility of the reference sources, and ease of use. In the learning process, user convenience must

be the main source of learning, because it is in accordance with the role of education and teaching, namely providing convenience in conveying knowledge and one of which is providing student attraction in the learning process of course.

Figure 7. Digital Encyclopedia Trial

Based on evaluations from course lecturers and student assessments, the digital encyclopedia demonstrates high practicality, confirming its feasibility for integration into science learning activities. The positive feedback from both educators and learners underscores its effectiveness as an innovative educational tool. Therefore, this digital encyclopedia is recommended for implementation in science education to enhance learning engagement and comprehension.

CONCLUSION

Based on the research findings and discussion, it can be concluded that the developed digital encyclopedia was designed following the four stages of the 4D development model (Define, Design, Develop, and Disseminate). This digital encyclopedia underwent a validation process and was found to be very valid according to expert evaluations, receiving scores of 93% from the language expert, 93.2% from the subject matter expert, and 95% from the design expert. In addition to its validity, the product also proved to be very practical. This was supported by the lecturers' assessments indicating high practicality, as well as student trials, which resulted in a score of 98.51% in the small group and 94.04% in the large group. Based on these findings, it is suggested that further research be conducted on digital encyclopedias with several materials in biology learning and also explore their long-term impact on academic performance and knowledge retention.

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