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DEVELOPMENT OF A BIOTECHNOLOGY ENCYCLOPEDIA BASED ON SCIENTIFIC LITERACY TO IMPROVE STUDENTS' SCIENTIFIC LITERACY ABILITIES UNIMED BIOLOGY EDUCATION PROGRAM

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ABSTRACT

The research aimed to assess the Biotechnology Encyclopedia's suitability as a learning resource for Biotechnology students, involving material, design, and learning experts. Developed using the ADDIE model, the study included sixth-semester students from the Biology Education Program at Medan State University. Sampling involved 56 students selected through simple random sampling. Data collection utilized questionnaires, tests, and interviews, analyzed quantitatively and qualitatively. Material and design experts rated the encyclopedia positively but suggested minor revisions, with 72% and 86% respectively in the "good" and "very good" categories. Similarly, learning experts and lecturer responses were in the "very good" category at 94% and 85% respectively. Student responses were overwhelmingly positive, with 87% in the "very good" category without revisions. T-test results showed a significant difference in scientific literacy abilities between the experimental and control classes (9.344 > 2.002), indicating the effective impact of the Biotechnology Encyclopedia based on scientific literacy.

KEYWORDS *Encyclopedia Book Development, Biotechnology, Scientific Literacy Ability*

INTRODUCTION

In the era of globalization, science and technology have developed rapidly. In this development, the Indonesian nation is required to prepare a generation that has quality human resources. Efforts to increase human resources who have competencies and skills are through education (Dewi, 2019). Therefore, education must be able to empower people to become people who can think creatively, independently, and can develop themselves and their society in a better direction (Harahap et al., 2023).

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Learning resources are all sources including tools, materials, devices, settings, and people that may be used by students either individually or in combination to facilitate learning activities and improve performance. Learning resources have an important role in determining the learning process so that learning becomes effective and efficient in achieving goals. Learning resources are defined as information presented and stored in various forms of media, which can help students learn as an embodiment of the curriculum.

In 21st century learning, students need to master material that is closely related to understanding the environment, health, economics, and the problems faced by modern society which are closely related to technology and progress. Science education is one way to prepare human resources who have life skills. One way to achieve this ability is to increase scientific literacy.

Considering the importance of scientific literacy, educating the public to have scientific literacy is the main goal in every science education reform. Scientific literacy views the importance of thinking and acting skills which involve mastering thinking and using scientific thinking in recognizing and responding to social issues. Scientific literacy is important for students to understand the environment, health, economics, modern society and technology. Therefore, measuring scientific literacy is important to determine the level of scientific literacy of students in order to achieve high or good scientific literacy so that the quality of education in Indonesia can improve and be able to compete with other countries.

Based on the results of the PISA (Program for International Student Assessment) assessment in 2015, Indonesian students are still below the average scientific literacy score among OECD (Organization for Economic Cooperation Development) countries. The average scientific literacy score in OECD countries is 493, while Indonesia has only reached a score of 403. Likewise, the 2018 PISA (Program for International Student Assessment) results placed Indonesia as one of the countries with low scientific literacy, namely ranking 74th out of 79 countries (OECD, 2018).

Based on the results of interviews with biology education study program students in their learning process, students felt bored when studying Biotechnology material. This is because when learning takes place, students are asked to translate biotechnology ebooks as a learning resource provided by the lecturer. Students find it difficult to understand the meaning, they only transfer the ebook reading results from the learning resources they translate. In fact, at the higher education level, the learning process is directed at course learning outcomes in the form of competencies formulated in the Indonesian National Qualifications Framework (KKNI) in the form of critical thinking competencies and problem solving skills.

Biotechnology is one of the mandatory courses with 3 credits in semester VI in the Biology Education study program, Department of Biology, FMIPA, Medan State University. The scope of biotechnology material is: history of development and scope of biotechnology, basic concepts of conventional and modern biotechnology, fermentation biotechnology and its applications, supporting methods for modern biotechnology and gene expression mechanisms, recombinant DNA technology (Genetic Engineering), environmental biotechnology, plant

biotechnology and agriculture, animal biotechnology, medical biotechnology, DNA.

Research conducted by Rahmadani (2018), the average score obtained by students in biotechnology material still has not reached the target of the National Education Standards Agency (BSNP) of 75. The results of this research also found that there are several schools that only have an average biotechnology score of 65 - 70. In line with Sumiar's (2014) research, students also experience difficulties in understanding the meaning of biotechnology, differentiating the meaning of the differences between conventional and modern biotechnology, remembering the names of microorganisms used in biotechnology products, understanding the meaning of reproductive engineering, understanding the meaning of tissue culture, as well as the differences between hydroponics and aerophone. According to Zetkas et al., (2016) students' difficulties in studying biotechnology material should not be considered as something normal and ordinary, so that there is no effort to improve them because understanding learning difficulties is an asset that can be used as a basis for adjusting learning programs. Student groups in general can also provide useful information for adjusting learning programs based on student individuality.

Based on an analysis of student needs in the Unimed Biology Education Study Program, around 57% of students experience difficulty in finding learning resources or literature regarding biotechnology based on scientific literacy. This condition is caused by the limitations of reference books which only explain biotechnology concepts, theories and processes without providing relevant examples. As a solution, researchers designed an encyclopedia as a comprehensive, easy to understand and interesting learning resource, equipped with pictures to clarify each concept. Thus, it is hoped that the encyclopedia can improve students' scientific literacy skills in understanding Biotechnology material.

An encyclopedia is a book that collects information or descriptions about various things in the fields of art and science, arranged alphabetically or by scientific environment (Prastowo, 2019). To support the development of students' activeness and thinking, the use of encyclopedias as teaching materials has been considered important (Hernawati, 2018). Encyclopedias provide a better explanation. Encyclopedias can also help explain everything as a phenomenon. The encyclopedia is equipped with scientific information and supported by original photographs. Komalasari (2011) stated that pictures or photos can provide a real picture to show actual objects, provide a learning atmosphere that is livelier and more accurate than words so that they can stimulate students' thinking abilities. Many people are interested in encyclopedias because the information provided in encyclopedias is light and comprehensive. Encyclopedias are able to provide visualizations that can attract students in the learning process, namely with pictures to help explain the material being studied. Encyclopedias have the function of enriching students' knowledge, skills and personality.

The explanation above makes it clear that there is a great need for development research as a learning resource in the form of a biotechnology encyclopedia based on scientific literacy. With these learning resources, it is hoped that it can improve students' scientific literacy skills, increase innovation, variety

and insight into knowledge about biotechnology material which is so close to the life of the environment around students.

According to Zega (2016), teaching materials based on scientific literacy must present science as dynamic science and as experimental science. Science process skills must be used to build a scientific basis and also need to be experienced by students so that they have aspects of practical application for making decisions in everyday life. This teaching material is prepared based on scientific literacy because scientific literacy is a knowledge and understanding of scientific concepts and processes that will enable someone to more easily make decisions with the knowledge they have. Literacy has a broad meaning, namely technological, political literacy, critical thinking and sensitivity to the surrounding environment. Scientific literacy is important for students to master in relation to what, why and how students can understand the environment, health, economy and other problems faced by modern society which is very dependent on technology and the progress and development of science.

Based on the explanation of the empirical and theoretical facts described above, the researchers conducted research entitled "Development of a Biotechnology Encyclopedia Based on Scientific Literacy to Improve the Scientific Literacy Abilities of Unimed Biology Education Study Program Students". In identifying problems, the problems faced include the unattractiveness of Biotechnology learning resources for 52% of students, difficulty finding literature in the form of scientific literacy encyclopedias by 83% of students, the lack of a scientific literacy approach in learning Biotechnology which is felt by 57% of students, and the inadequacy of existing learning resources. increasing students' scientific literacy, as found from the results of interviews. Within the boundaries of the problem, the research focuses on students of the Biology Education Study Program at Medan State University, especially in Biotechnology courses. The encyclopedia developed will be validated by material, design and learning experts, and assessed by lecturers and students. Trials were conducted to evaluate the effectiveness of the encyclopedia. The problem formulation includes evaluating expert responses and product effectiveness, while the research objective is to understand the feasibility of the product and expert responses, as well as determine its effectiveness. The benefits of research include theoretical benefits as a reference for educational and practical development for students, lecturers, universities and researchers in improving the quality of learning and developing learning resources in the field of Biotechnology.

RESEARCH METHOD

This research was conducted at Medan State University, involving sixth semester Biology Education Study Program students. Carried out in the even semester of the 2022/2023 academic year, this research covers the preparation and implementation stages of encyclopedia development from May to August 2023, with validation carried out in September-October 2023, and effectiveness testing in December 2023. Research subjects include all Education Study Program students Biology with a sample of 56 students from PSPB B and PSPB E classes, using a simple random sampling method. The research and development method used is

Research and Development (R&D) with the ADDIE model. Data collection was carried out through test and non-test techniques, including observation, interviews, document data and questionnaires. The validity of the instrument was tested using point biseral, reliability using the KR-20 formula, as well as the criteria for difficulty and discrimination. The product effectiveness test was carried out using a Nonequivalent Control Group Design, using the independent sample t-test.

RESULT AND DISCUSSION

Research Results

Analysis

The main step taken in this research is the analysis stage including curriculum analysis, student characteristics and learning resource analysis. Analysis of the curriculum used in the FMIPA Biology Study Program, Medan State University, namely a curriculum based on the Indonesian National Qualifications Framework (KKNI) integrated with the independent learning and independent campus curriculum (MBKM). The Unimed KKNI curriculum emphasizes optimal student involvement in the learning process so that it is hoped that mastery of student science concepts will be more complete and special skills will be better mastered. One of the strategies used in implementing the KKNI curriculum at Unimed is by giving 6 types of assignments to students. The basic competency that must be achieved is that students are able to explain and describe the development and role of biotechnology in various fields.

The characteristics of the students analyzed were firstly about stability in their personality when studying biotechnology, secondly the students' needs regarding the need for a biotechnology encyclopedia based on scientific literacy as a learning resource. The following is table 1 of the results of a questionnaire conducted on needs analysis by Biology Education Study Program students.

Table 1. Results of Student Needs Analysis Questionnaire

Questionnaire	**Student**	
	YES	**NO**
Have you ever had difficulty understanding the Biotechnology course?	**83%**	**22%**
Questionnaire	**Student**	
	YES	**NO**
Can you understand Biotechnology material with just one book?	**4%**	**96%**
Have you ever studied Biotechnology material using various other learning sources?	**100%**	**-**
Do the learning resources you are currently using attract interest in studying Biotechnology material?	**48%**	**52%**
Would you like it if Biotechnology learning was presented using a variety of varied learning resources?	**100%**	**-**
Do you think the availability of learning resources in the form of printed books is important in the learning process?	**100%**	**-**
Do you wish to have learning resources that provide answers to questions that require knowledge and facts about Biotechnology?	**100%**	**-**

Do you wish to have learning resources that discuss various phenomena that are used as subjects of discussion and presented in printed form?	**100%**	**-**
Do you wish to have a learning resource as a guidance service for further materials for readers on the topics discussed in the Biotechnology material?	**100%**	**-**
Can the learning resources you currently use train your scientific literacy skills?	**30%**	**70%**
Do you study Biotechnology material based on concepts or theories, problem solving, practicing logical thinking, and describing the impact of science on society and the relationship between science and technology?	**43%**	**57%**

	Student	
Questionnaire	**YES**	**NO**
Do you want to have a biotechnology encyclopedia book based on scientific literacy?	**100%**	**-**
Can a biotechnology encyclopedia based on scientific literacy stimulate you to practice scientific literacy skills?	**100%**	**-**

Based on the questionnaire data obtained, 83% of students experienced difficulties in studying Biotechnology. As many as 22% of students understand Biotechnology material by using references from books only. As many as 52% of students stated that the learning resources currently used had not attracted interest in studying Biotechnology material. As many as 70% of students stated that the learning resources currently used had not trained students' scientific literacy skills. As many as 57% of students said that the current learning resources used were still minimal regarding scientific literacy. As many as 100% of students wanted to have books based on scientific literacy on Biotechnology material and 100% of students said that having books based on scientific literacy could stimulate them to have scientific literacy skills. From these results it can be concluded that scientific literacy-based Biotechnology encyclopedia learning resources are needed by students in order to stimulate scientific literacy abilities.

Design

At this stage, researchers designed learning resources which were developed in the form of a Biotechnology encyclopedia book based on scientific literacy to train the scientific literacy skills of students in the Biology Education Study Program, Medan State University.

Development

The development stage is the stage carried out to produce a product that will be developed from the initial design that has been designed. The stages carried out by researchers in developing an encyclopedia are: (1) Making an encyclopedia in terms of material, design and learning, which will show differences with the textbooks used at Medan State University. (2) Conduct an encyclopedia review by validating it by 2 material experts, 2 media experts and 2 learning experts. (3)

Improve the encyclopedia in accordance with suggestions and input from material, media and learning experts so that there is a comparison of the initial book and the book after revision. (4) Conduct assessments on Biotechnology lecturers and test students to obtain opinions regarding the suitability of the encyclopedia being developed. (5) Improve the encyclopedia according to suggestions and input from Biotechnology lecturers.

Implementation

The implementation stage was carried out in classes E and B in the sixth semester of the 2020 Stambuk Biology Education Study Program, Medan State University, where class E was the control class and class B was the experimental class. In the ongoing learning process, *a pretest will be carried out* for the two classes regarding Biotechnology material in May 2023.

In class E (control), learning is carried out conventionally or without using the Biotechnology encyclopedia that was developed. The learning system is implemented using the lecture method, namely group percentages on Biotechnology material, then ends with a question and answer session by students who want to ask questions.

In class B (experimental), learning is carried out using a Biotechnology encyclopedia based on scientific literacy in December 2023. The learning system is implemented using a scientific approach, namely observing events in the surrounding environment, asking questions related to Biotechnology, collecting information from various sources. One of the sources used is Biotechnology teaching materials and Biotechnology encyclopedias, then processing the information that has been collected to obtain conclusions in the form of new knowledge. The next step is to communicate the results of the learning process that has been carried out by expressing opinions clearly, concisely, concisely and practicing good and correct language. Next, the *posttest* in both classes, namely control and experiment, will be carried out in December 2023.

Evaluation

The final stage in the development process in this research is an evaluation of the Biotechnology encyclopedia product based on scientific literacy. The purpose of this stage is to see the quality of the product and process before and after implementation. According to Robert Maribe Branch (2009), it is at this evaluation stage that product quality can be determined through three aspects: 1) *Perception* , 2) *Learning* (results) and 3) *Performance* (attitude). The perception aspect can be seen from the responses of lecturers and students when testing products at the development stage. The attitude aspect can be seen in the learning process, however, during the research, researchers did not assess student behavior when using encyclopedia products due to limited research time, so the research was carried out virtually.

Discussion

The results of the needs analysis from the questionnaire distributed to students showed that as many as 83% of students said they had difficulty understanding the

Biotechnology learning material. The results of the same research also conducted by Zega (2022) stated that students faced many difficulties with biotechnology lecture material because on average it was abstract. Students have difficulty visualizing the process of tissue cloning in animals. Apart from that, there are many challenges faced by students in biotechnology material, especially cloning material, gene therapy techniques, genetic engineering and bioethics due to students' poor understanding of ideas.

If we look at the learning resources currently used , as many as 52% of students stated that they were not interested in studying Biotechnology material. This result is in line with Widyastuti's research (2017), the results of an analysis of student activities in learning biotechnology, that learning biotechnology is hampered by a lack of resources and curricular materials, and a lack of teaching time. Conditions like this affect the physical performance of students taking biotechnology courses; The lack of student motivation and interest in learning is shown by the low percentage of students completing assignments given by lecturers such as practicums and homework, thereby hampering learning outcomes for CPMK courses). Thus, if students understand well and are able to make good judgments regarding biotechnology, and can act appropriately towards biotechnology.

This result is supported by research by Widyastutui (2017), that the low level of student mastery in this science could be caused by students' difficulties in studying biotechnology in lectures, so thorough preparation is needed in learning in this field. It is suspected that various causes of low learning outcomes in biotechnology include elements within the students themselves and external circumstances. Students continue to struggle with typical biology and biotechnology material such as making tempeh and know when they have to go directly into the field, often taking advantage of lectures, or explaining concepts. Meanwhile studying biotechnology not only requires conceptual understanding but also practice.

Apart from that, regarding modern biotechnology there are limited facilities/equipment suitable for studying biotechnology, requiring relatively large equipment, materials and costs, so that in reality genetic engineering cannot be applied as a practical activity. From this it can be said that students' mastery of biotechnology subjects and the way they are delivered in learning on campus greatly influences students' understanding. Therefore, learning must be carried out with thinking and acting skills which involve mastering thinking and using scientific thinking in recognizing and responding to social issues by providing visualizations that can attract students in the learning process, namely with pictures or photos to help explain the material. what is studied and shows the actual object, provides a learning atmosphere that is more lively and more accurate than words, can stimulate students' thinking abilities so that students can enrich students' knowledge, skills and personalities by discovering facts, concepts, principles and applications.

In this research, as many as 100% of students who had filled out a needs analysis questionnaire for books said that it was necessary to develop an encyclopedia book for the Biotechnology course. The book developed in this research is structured and systematically adapted to the indicators of the

Biotechnology course. The book developed has gone through a validation and revision process from expert validators. This validation aims to seek approval and validation from validator experts regarding the suitability of the book that has been developed.

Aspects of Material Expert Assessment

The aspect of assessment by material experts on the Biotechnology encyclopedia based on scientific literacy aims to improve the content of the book material. After revisions based on material expert input, the quality of the book increased with an average suitability score of 72% (Sri, 2020; Zunaidah, 2014). Previous research also showed similar results, confirming that this encyclopedia is suitable for use as teaching material (Agriansyah, 2023). Validation results by various experts show that this encyclopedia is in accordance with competency standards and learning objectives (Ani Cahyadi, 2019; Supriadi, 2017). This is important because choosing the right learning resources, including media such as encyclopedias, can increase the effectiveness of the learning process.

Aspects of Media Expert Assessment

The aspect of assessment by media experts on the Biotechnology encyclopedia based on scientific literacy aims to improve the book design. After revision, the average score for the seven assessment components was 86% in the very good category, but needed slight revision (Ariyanti, 2018). For example, revisions to the cover design and placement of images of the book's contents. This encyclopedia is considered very good because it can attract students' attention and make it easier to understand biological concepts, including Biotechnology material (Trisnawati et al., 2020). Presenting clear images and writing, with the addition of color variations, can stimulate students' learning motivation (Hakim, 2015). Color is also an important factor in presenting learning resources, and attractive designs are an integral part of visual media such as encyclopedias (Arsyad, 2011).

Aspects of Learning Expert Assessment

The assessment aspect by learning experts of the Biotechnology encyclopedia based on scientific literacy aims to improve the presentation of the book. After revision, the average score of the nine assessment indicators reached 94% in the very good category, but required slight revision (Supriyadi & Lismawati, 2018). Suggestions from learning experts include adding inner cover pages and authors, improving illustrations and text to make them clearer, as well as adjustments to the scientific approach. This encyclopedia is considered very good in presenting the material, with appropriate images that make it easier for students to understand. Clear and relevant images enrich the validity of the material and increase the attractiveness of learning.

Aspects of Teaching Lecturer Assessment

The assessment aspect of the lecturer regarding the Biotechnology encyclopedia based on scientific literacy aims to provide input into the learning process. Lecturer responses to books are categorized into four assessment

components, including appropriateness of content, presentation, language, and efficiency towards scientific literacy. Even though there were differences in assessments between the two lecturers, the average eligibility score reached 85.5%, indicating a very good category but requiring slight revision. Research by Nuraida & Nisa (2017) also shows that the encyclopedia developed is worth testing based on responses from university lecturers in the Biology Education study program. The assessment results confirm that the Biotechnology encyclopedia based on scientific literacy is suitable for use as a learning resource for students, in accordance with the product validity criteria measured by Kristiawan et al. (2014).

Effectiveness of the Biotechnology Encyclopedia Based on Scientific Literacy

The effectiveness of the Biotechnology encyclopedia book based on scientific literacy was tested using the Independent T-Test, which showed a significant difference in scientific literacy abilities between the experimental class and the control class ($t_{count} = 9.344 > t_{table} = 2.002$, $\alpha = 0.05$). This confirms that the encyclopedia effectively influences students' scientific literacy abilities. These results are in line with research by Sufyan (2023), which found that the product developed had high effectiveness in improving learning. These findings are supported by research by Mulyani and Armiati (2020), which shows that the use of technology-based encyclopedias is effective in increasing student motivation and learning outcomes in high school. According to Moasaroh (2010), the effectiveness of an activity can be seen from achieving the expected goals, and in this context, the effectiveness of the encyclopedia is demonstrated through increasing students' scientific literacy abilities.

Aspects of Student Assessment

The biotechnology encyclopedia book based on scientific literacy has gone through stages of validation, revision and testing by expert validators and lecturers, as well as individual, small group and limited group trials to obtain student responses. Students assess this book based on the appropriateness of the material, presentation, language and images, encyclopedia content, and appearance. The trial results showed that the average percentage score was very good, with the individual group reaching 87%, the small group 86%, and the limited group 88%. Student responses show that this book can increase their knowledge of Biotechnology material, with clear images, text and language. They found this book interesting and helpful in understanding scientific concepts. This finding is in line with the results of previous research and shows the importance of science education that pays attention to scientific literacy in improving students' critical thinking skills and scientific understanding (Abidin et al., 2021; Fakhriyah et al., 2023; Yuliati, 2017).

CONCLUSION

The conclusion of this research shows that the biotechnology encyclopedia book based on scientific literacy has been assessed as good by material experts with a validation percentage of 72%, very good by media experts with a percentage of 86%, and very good also by learning experts with a percentage of 94%. The

effectiveness test shows a significant difference in scientific literacy abilities between the experimental class that uses the Biotechnology encyclopedia and the control class, confirming that the use of this encyclopedia is effective in improving students' scientific literacy abilities. Therefore, it is recommended to also look at students' attitudes during the learning process by using assessment observation sheets, as well as ensuring that this encyclopedia book is able to attract the reader's attention and provide scientific benefits that can be applied in the development of Biotechnology.

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