Research Implementation of the Milkfish Feed Development from the Edible Mushrooms for a Digital-Based Module in Biotechnology Concept for High School Students

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Abstract

This study aimed to analyze the results of research on the content of edible mushrooms as milkfish feed to be implied as a digital module, a learning source for biotechnology concepts for high school students. The study was carried out through stages: identifying the problems in biotechnology concepts learning activities in four state senior high schools in Banten Province, identifying research methods and products through experiments, choosing and adapting research findings as the learning source content, and applying and developing research findings as learning. An interview grid and questionnaire were used to collect the data, and a qualitative analysis was used to interpret the questionnaires' results. The research results were in the form of a digital-based module in biotechnology concepts for high school students. The module contains activities that create student interest and motivation and help students master the concepts. In addition, the module's content was a research finding on the milkfish feed development from the edible mushrooms in the form of process and product. It can be concluded that a digital module on biotechnology concepts has been developed and can be used as a learning source for high school student.

Keywords: Biotechnology, Digital Module, Edible Mushroom, Milkfish

INTRODUCTION

Research results primarily related to biology can be used as learning sources and materials to support student learning activities. The new research findings will enrich student information and give a new perspective on learning biology. Generally, student activities in biology subject include student engagement in class, in-class group interactions, laboratory activities, and field studies tasked with learning about the natural world (Humphrey & Wiles, 2021; Marley et al., 2022). In addition, students' motivation, and confidence, should be increased through the educational process, encouraging meaningful learning, problem-solving, and critical thinking (Armbruster et al., 2009; Manuaba et al., 2022). Therefore, it is crucial that teachers, who serve as learning facilitators, link what students learn in the classroom to what they see daily. Widyasari et al. (2013) and Alhawiti (2023) proved that involving students directly in the learning process could improve learning skills and students' long-term memory for comprehending the material. Long-term memory possessed by students can help solve problems in everyday life by digging back into students' memories.

The milkfish feed development from the research of edible mushrooms can be used as a biology learning source. The research was based on the idea that edible mushrooms contain nutrients that benefit humans and may help support the nutritional requirements of other organisms, for example, milkfish (*Chanos chanos*) as one of the potential fish produced in Banten Province. Milkfish is one of Banten's specialties processed into sate bandeng, often used as souvenirs for tourists. Sate bandeng has many flavors, such as savory, sweet, salty, and spicy. The way of making it is also diverse, some are steamed, and some are burned. Likewise, the spices used are coconut milk, and some are not. Seasonings and manufacturing processes determine the quality and durability of sate bandeng (Meutia et al., 2018).

A significant increase in consumer interest in milkfish due to its delicious and affordable meat taste will impact milkfish aquaculture, especially in milkfish feed. Fish feed quality is key in impacting the aquaculture water environment (Kong et al., 2020; Rombenso et al., 2022; Zlaugotne et al., 2022). Feed requires good nutrition, such as carbohydrate, fat, and protein levels in milkfish (Beveridge et al., 2013). So far, the feed requirement is supplied with commercial feed, which costs a lot. Therefore, there needs to be an alternative fish feed that meets the

nutritional composition for the growth of milkfish.

The information based on the research findings can also be connected to the biotechnology concepts for students in senior high school. According to the 2013 curriculum, the essential competencies for the biotechnology concept are essential competence 3.10 for the cognitive domain: analyzing the principles of Biotechnology and its application as an effort to improve human welfare and essential competence 4.10 for the psychomotor domain: presenting an experimental report for conventional biotechnology principles application based on the scientific method. However, it was revealed through a need analysis carried out in four public senior high schools in the Banten province that the teaching materials and learning resources provided for the biotechnology concept needed to be revised to support their academic achievement. Students can grasp the learning process for this biotechnology idea. However, the teaching materials and learning sources must be more attractive to increase students' motivation to comprehend the information. According to National Research Council (US) Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century (2003), adaptable modules from research results can be used for knowledge enrichment. It can be a desirable complementary means of strengthening the biology subject.

Good quality curricular materials and adequate resources significantly affect student performance on standardized evaluations (Allen & Tanner, 2004). Rodriguez et al. (2022) suggested integrating natural material resources into the educational system as a suitable choice for education. According to Farhana et al. (2021), learning materials are tools used in the learning process. In order to accomplish predetermined learning objectives, teaching materials typically contain materials, learning methods and evaluations that are organized systematically and interestingly (Magdalena et al., 2020). Learning materials are highly recommended because they can provide students with an active learning experience. So that the learning objectives that have been designed can be achieved efficiently and effectively (Daryanto, 2016; Ghani et al., 2021). According to Violandini (2019), learning materials have various types, such as books, magazines, modules, student worksheets, handouts, and video or audio teaching materials.

The learning module is one of the learning materials used, and compared

to others, the learning module supports the independent learning process. Tohidi et al. (2019) suggested that modules contain many advantages for teachers and students, such as flexibility, accessibility, transferability, easiness, learner accountability, learner motivation, cost-effectiveness, a safe learning environment, and time-saving, in line with today's educational paradigm, which views students as learning objects and teachers as learning facilitators. In addition, as the world of education evolves, modules that were once merely printed instructional aides are becoming more sophisticated and innovative by sometimes modifying the growth of science. Some of these improvements or inventions feature digital copies of their modules that may be utilized on computers or gadget. In similar line of research, the finding by Putra et al., (2022) highlighted on the use of technology-based techniques using adaptive learning will give students more interesting learning experiences.

Digitalization's influence on daily life profoundly affects every aspect of society (Lindberg et al., 2021; Van Veldhoven & Vanthienen, 2022) including education, which demands that students and teachers follow this fundamental change process. Once the technology is incorporated into the curriculum, students and teachers will perceive its efficacy. The advantages of digital-based modules as teaching material and learning sources are that they are interactive, simplify navigation, load graphics, music, video, and animation, and come with formative exams or quizzes (Mulyasari & Sholikhah, 2021). Furthermore, these multimedia technologies may make abstract subjects more concrete and exciting by accommodating various learning styles and improving students' understanding and information retention (Abdulrahaman et al., 2020). In addition, using digital-based modules enables feedback and encourages student participation in the learning process. The study aims to implement the results finding of milkfish feed development from edible mushrooms as a teaching material as a digital-based module in biotechnology concepts so that it can be used for high school students to study biotechnology concepts.

METHOD

The study was conducted from November 2021-May 2022. The methods were carried out through several stages. The first stage was to identify the problems in biotechnology concepts learning activities in four state senior high schools representing district and city in Banten Province (SMAN 4 Kota Serang, SMAN 6 Kota Serang,

SMAN 1 Pabuaran, and SMAN 1 Kibin) using interview grid, and questionnaire students and biology teachers filled out. The items consisted of the perception of teaching material and learning sources based on student and teacher points of view and studied experience. Test the instrument's validity in this study conducted with content and construct validity and qualitative analysis used for interpreting the results of questionnaires.

The next following stages were carried out for implementing research finding as module content, according to Suhardi (2012), were completed in three steps:

- Identifying research methods and products
- Choosing and adapting research findings to serve as educational resources
- Applying and developing research findings as educational resources

Prior to research findings of milkfish feed development from Edible Mushrooms, an experiment method has been completed in October-December 2021.

RESULTS AND DISCUSSION

As a result of the analysis from the interview process and questionnaire, teaching biotechnology is challenging based on the teacher's perspective. Biotechnology is a concept in Biology with a high level of conceptual complexity. As stated by Parsley & Siedow (1999), biotechnology consists of a gradient of technology ranging from long-established and widely used traditional and conventional biotechnology to novel techniques of modern biotechnology, such as enabling genetic manipulation of organisms. Studying biotechnology will allow the student to develop skills and investigate related issues, for example, food production, health, environment, etc.

Sometimes teachers also need help finding a suitable model to deliver the concept. In order to satisfy the various learning requirements of their students, promote knowledge, encourage active participation, create a good learning environment, match instructional goals, and demonstrate professional experience, teachers must select an appropriate teaching model (Kim et al., 2019). Teachers may enhance the teaching and learning process and assist students in reaching their academic objectives by carefully choosing the suitable model.

In addition, their English language skills needed to be adequate since they needed help keeping up with the most recent material since literature from scientific publications and textbooks was printed in English. Textbooks remain the most significant source for revealing what students will learn during the educational process. For students to correctly acquire the ideas and relate

them to one another in this context, the scientific quality, language, visuals, diagrams, and models, as well as the context and technical and physical characteristics employed in textbooks, all play essential roles (Barış & Kırbaşlar, 2015).

Students also need help while learning biotechnology. The concept is abstract, and much material should be mastered quickly. Before the student experiment, conventional biotechnology was easily found in the surrounding environment. Due to their relative ease, the teacher usually instructed the student to experiment with food production, such as yogurt, tempeh, nata de coco, and doughnut. The simplified procedures on the products should provide a basic overview of the processes related to the role of microorganisms. On the contrary, when it is related to modern biotechnology, it is not easy to carry out as it needs high technology, which did not become available in school.

The suitability of the subject content and the student's developmental stages must be considered when choosing a learning resource. After a requirements analysis, the learning source materials used to implement the digital module were selected (Figure 1). Unfortunately, the learning materials offered for ideas in biotechnology could be more enjoyable. In addition, the vocabulary employed is challenging to follow, and there are far too many explanations without illustrations. Figure 1 shows that the learning module received the highest percentages, 80% and 50%, respectively, based on the findings of the questionnaire on the needs of biotechnology learning sources supplied to teachers and students as respondents. In order to improve student learning outcomes, Wahyuni et al., (2016) found that learning modules on the concept of biotechnology with experimental activities have a positive effect on the development of skills in students. Learning through modules also makes concepts and material easier to understand

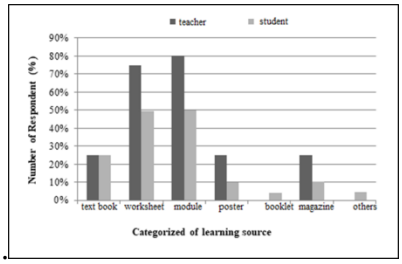

Figure 1. Results of the questionnaire on the required learning resource

Information and all data based on research activities must be clear about the possible availability of the item and the problems presented to be incorporated as

a learning resource. The research focuses on milkfish and edible mushrooms straw mushroom/*Volvariella volvacea*, king oyster mushroom/*Pleurotus erygii*, and enoki mushroom/*Flammulina velutipes*). The study revealed issues with how the content of the edible mushroom feed affects milkfish growth.

Research findings may be categorized into two aspects a procedure and a product. Facts and ideas discovered are called research products (Sabarudin, 2018). The information was obtained from the study's findings and related to how mushrooms' nutritional content can impact fish development. In contrast, the product in the form of a concept results from a generalization of fact products.

The edible mushroom used in the research is essential in Indonesia and worldwide. *Volvariella volvacea, Pleurotus erygii* and *Flammulina velutipes* are the edible mushroom, is a highly nutritious food source that is widely cultivated on a commercial scale in many parts of Asia using agricultural wastes as growth substrates (Bao et al., 2013; Chen et al., 2019; Christodoulou et al., 2023; Banerjee et al., 2020). The nutritious value of mushrooms can promote the growth of fish.

Mushrooms are frequently referred to as neutraceuticals because of their medical and nutritional benefits. On a dry weight basis, mushrooms are regarded as an excellent source of digestible proteins (10–40%), carbs (3–21%), and dietary fiber (3–35%). However, they are deficient in amino acids like cysteine and methionine that contain sulfur. In addition, mushrooms contain vital elements, including iron, copper, zinc, and manganese, which are crucial to biological processes (Gogavekar et al., 2014). Therefore, according to Rangel-Vargas et al. (2021), mushrooms are the perfect candidates to be included in the feed to improve their nutritional profiles due to their valuable nutritional contents of protein, dietary fiber, and bioactive substances.

In this study, mycelial biomass rather than mushroom fruiting bodies were employed as the raw material to avoid conflicting with the demands of mushrooms for human consumption. It is for the effective use of resources also. Since the mycelium may be produced and collected without compromising the fruiting bodies that are meant for human food, this encourages resource efficiency (Chang et al., 2019). The use of biomass from fungal mycelia, such as *Aspergillus* spp. (Rousta et al., 2021). *Pleurotus* sp. (Sartori et al., 2015) and *Rhizopus* sp (Starzyńska-Janiszewska et al., 2020) for feed or food reasons has been employed in preparing food for a long time. Therefore, it has designated as Generally Recognized As Safe (GRAS)

microorganisms (Karimi et al., 2021). The study results were the composition of nutrients based on proximate analysis, growth length, and survival rate are presented in Table 1. The control used in this study was commercial feed available on the market.

The highest value of fish length was with the feed treatment of straw mushroom, followed by enoki and king oyster mushroom, which were not significantly different from the control. Fat and fiber's nutrition content is higher than the control's, while the protein and carbohydrates are contrary. Based on the research, edible mushrooms can be utilized as a milkfish feed component to support growth. Moreover, the study's results can inform the public, especially fish farmers, in choosing feed technology as an alternative that can meet the nutritional needs of milkfish.

It is essential to become knowledgeable about feed technology as fish farmers can provide the right nutrition, ensure feed quality and safety, optimize feed production costs, adopt sustainable practices, promote fish health, and increase productivity and profitability in their aquaculture operations (Ragasa et al., 2022).

The resulting finding also can be used as new information for the student for biotechnology learning.

Table 1. Nutritional content of edible mushrooms feeds and effect on the growth of milkfish

Treatment	Nutritional Content (%)				Milkfish larva Length (cm)	Fish Survival Rate (%)
	Carbohydrate	Protein	Fat	Fiber		
C	54.80	30	3	4	6.208±0.101[b]	32.52[b]
JER	43.27	13.95	16.03	15.43	6.400±0.338[b]	78,23[a]
JEN	44.36	3.60	8.96	19.20	6.133±0.063[b]	63,53[a]
JM	38.33	21.70	13.92	14.18	6.483±0.201[a]	90.63[a]

C: control, commercial feed, JER: King oyster mushroom, JEN: Enoki mushroom, JM: Straw mushroom. Values followed by the same letter are not significantly different at $P<0.05$ according to Tukey's least significant difference test.

The study's findings, which include items and procedures, are then evaluated for compliance with the curriculum's requirements for student mastery. The condition is visible from essential competence 3 and essential competence 4's fundamental abilities in the cognitive and psychomotor domains. Competency Achievement Indicators (GPA) were created based on those competencies to facilitate high-order thinking skill tiers starting at the lowest level, C1 through C4. The GPA, e.g., explains the definition of biotechnology (C1), defines its fundamental principles and processes (C2), differentiates its types (C2), examines the impact of biotechnology on genetic engineering (C4), and carries out experiments using conventional biotechnology principles

for biotechnology product (P5). According to Scristia (2019), in determining indicators, teachers must consider achieving a minimum competency and developing it according to student needs, particularly to develop high-order thinking skills. This information and findings as products and processes derived from the research align with what students need to learn about biotechnology concepts at school.

To meet the demands of the twenty-first century, it is regarded reasonable to package educational materials into digital modules. It is generally known that, information and communication technologies (ICT) have altered every aspect of life, from how to work and communicate to how to educate the student (Cabero-Almenara et al., 2022). Andrian (2019) argues that education is becoming more crucial in the twenty-first century to ensure that students have the knowledge and innovations necessary to generate competent human resources. This has led to the adaptation of present learning to meet the demands of 21st century education.

Developing a digital-based module in biotechnology concepts based on research findings on milkfish feed development from edible mushrooms as learning media was preceded by designing the module according to the 2013 curriculum. The digital module generally contains Biotechnology as a basic concept, conventional and modern biotechnology, and the role of biotechnology in life. The information is presented clearly and accompanied by engaging multimedia to improve students' motivation and comprehension. In twenty-first-century classrooms, multimedia environments are crucial for effective learning and teaching (Alobaid, 2021). Interactive quizzes, music, and video are example of the module's interactive and adaptable programs and examples of resources using a self-study method.

The module also contains several activities to create student interest and motivation to argue and determine the level of student mastery of the biotechnology material presented. For example, after watching movies related to biotechnology in life, there are activities in the module that incorporate a questioning element by providing students with higher-order thinking questions instead of a typical query that heavily relies on memorization. As a result, learning across subject areas can be improved. The exercise can allow students to generate in-depth explanations based on analysis (Sun et al., 2012). It can enhance their learning by providing an example of effective inquiry and encouraging them to do so.

Furthermore, the digital module provides instruction to assist students in learning independently. The digital form of the module is defined with a web-based system and compatible with internet servers, allowing the user to easy connection with programs like multimedia sharing.

According to Puckett and Black (2000), authentic assessment considers teaching, learning, and assessment as continuous, intertwined processes that coincide and significantly impact one another. Moreover, Anderson et al., (2022) analyzed that authentic assessments can be used as one approach to develop student's competence. Authentic assessments demand learners to use their knowledge and abilities to solve challenging issues, finish tasks, or generate meaningful work, in contrast to typical tests that place a heavy emphasis on memorization or regurgitation of material (McArthur, 2023). The authentic assessment for this module evaluates students' practical competence and behavior in addition to their academic knowledge. The assessment of all student activities is how this component is applied to the established program.

Through the utilization of digital module, biotechnology concept which considered difficult by most students, learning process will be easier. Student will capable to integrate the concepts and understand complex biotechnology materials as the example provided is easy to understand.

CONCLUSION

The findings of the research on the production of edible mushrooms as milkfish feed have been assessed as both a process and product. The material was then deployed as a digital-based lesson in biotechnology topics. The module includes activities that pique students' attention, motivate, and assist them in mastering the subjects. High school students can utilize the developed digital module as a learning source

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