

# The Development Project Based-Learning Food Microbiology E-Module Based on The Study of Kombucha Fermentation

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## ABSTRACT

This research is research and development based on Lee and Owens' design that aims to develop a valid and practical food microbiology electronic module based on Project-Based Learning (PjBL). The research and development consisted of five steps: analysis, design, development, implementation, and evaluation. The validity of e-module was assessed by content expert, media and teaching material expert, and biology education practitioner. The practicality of e-module was assessed by The State University of Malang students who had joined food microbiology course. The instruments of this research were validation sheets of content expert, media and teaching material expert, biology education practitioners, and student questionnaire sheet responses. The development outcome showed that the validation of the content experts, media and teaching, and biology education practitioner give a percentage of 100%. The outcome of the practicality of e-module showed that the individual trial gets a percentage of 92,44%, small group is 90,96%, and the field is 92,96%. According to the outcomes, it can be inferred that e-module have filled the validity and practicality necessity to be applied as teaching material in food microbiology courses.

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The COVID-19 pandemic has caused universities to take precautionary measures and protect the civitas academia by changing the learning process to online learning (Sahu, 2020). Changes in academic activities from offline to online at universities cause significant disruptions in the learning process (Ivanov, 2020). One of the universities still implementing blended and online learning is The State University of Malang. During the COVID-19 pandemic, practicum at microbiology laboratory could not be carried out. Practicum activities are converted into independent assignments or practicum activities in their respective class. This causes students to need help developing skills optimally. This statement is supported by the analysis of 21<sup>st</sup>-century skills needs and student learning outcomes which are classified as low.

The application of technology in learning or e-learning can be used to deal with learning disruptions due to the COVID-19 pandemic. Learning must be designed with multiliteracy pedagogical planning and have various competencies, including mastering ICT to access information, communicating information to the public, thinking critically, creating opportunities from problems, and having good problem-solving skills (Holloway & Gouthro, 2020). One form of applying technology in learning is using electronic teaching material.

The needs analysis results for food microbiology lecturer show that learning has used books and scientific article as teaching materials and power points as teaching media. The learning method in food microbiology course uses discussion and practicum methods. Practicum activities are carried out by following the practicum manual and project-based. However, the lecturer has determined students' projects and has yet to implement project-based learning based on research results. The needs analysis results show that interactive teaching material must still be available.

Electronic teaching material such as electronic module (e-module) can help online learning. E-module can help learning to be more exciting and interactive (Prasetya, 2021) because e-module can be supplemented with animation (Arsal *et al.*, 2019), audio, music, and video (Prasetya, 2021) and students interact with e-module (Abidin, Zainal & Walida, 2017). The interaction between e-module and students occurs due to evaluation activities and feedback on the answers given by students (S.Sirate & Ramadhana, 2017).

The results of the student need analysis showed that 78.9% of students needed e-module as teaching material and 94,7% were interested in e-module based on kombucha fermentation research and its antibacterial activity. Kombucha fermentation and its antibacterial activity were chosen because students have only learned about nata de coco and Tempe fermentation. Students need to be introduced to other fermented products with more complex fermentation processes and have antimicrobial activity.

Using research results as teaching materials contains information obtained from direct observation in the field to provide an authentic experience to students (Habibi *et al.*, 2016). Teaching materials based on research results can give contextual learning to students. Contextual learning can make learning more active (Rahmawati *et al.*, 2021), increase student understanding and provide information about findings that can be discussed (Anggraini *et al.*, 2022).

Teaching material such as e-module can help implement learning model more effectively. One of the appropriate learning models to implement during online learning due to COVID-19 pandemic is Project-Based Learning (PjBL). PjBL as a dynamic learning model facilitates students to investigate real problems actively, creating a challenging learning atmosphere and increasing the depth of understanding (Prasetya, 2021). Implementing PjBL during distance learning can increase students' motivation (Lesnowati & Hafifi, 2021) and student self-efficacy (Randazzo *et al.*, 2021). Applying blended PjBL during online learning can improve students' creative thinking skills (Yustina *et al.*, 2020).

This study aims to produce a PjBL e-module based on the results of kombucha fermentation and its antimicrobial activity research for use by students in the food microbiology course. Through e-module development, students are expected to be able to study independently, evaluate achievements through practice and get feedback to increase understanding.

## METODE

This research is research and development with Lee & Owens (2004) model which consists of 5 stages: analyze, design, development, implementation, and evaluation. The research instruments used were validation sheets for material experts, media and teaching materials, biology education practitioners, and students' response questionnaires given to biology undergraduate students in the faculty of mathematics and sciences, the State University of Malang, who had programmed food microbiology course. Data analysis was done using descriptive qualitative analysis through responses from validators and test subjects and quantitative descriptive analysis of validation values by experts. The results of data analysis were interpreted based on assessment criteria adapted from Akbar (2017). The results of material validation must reach a value of 100% so the e-module can be used without revision. There are five test decision results in media validation, field practitioners, and student responses.

**Table 1. Development Product Validity Criteria**

Percentage Scale	Criteria	Desc ription
85,01%-100,00%	Very Valid	May be used without revision
70,01%-85,00%	Valid	May be used with minor revision
55,01%-70,00%	Less Valid	May be used with major revision
40,01%-55,00%	Invalid	Should not be used
25,00%-40,00%	Totally Invalid	Should not be used

**Source: Adaptation Akbar (2017)**

## RESULTS

The research and development phase results with Lee and Owens development model consist of analysis, design, and development stages.

### Analysis

The needs analysis results for students show that the teaching materials used in food microbiology course are textbooks, scientific articles, modules, and YouTube videos. These results are supported by the need analysis for food microbiology lecture, which showed that teaching materials used are books, scientific articles, and power points compiled by themselves. The learning model implemented is project-based learning. However, projects carried out by students have been determined by lectures, so they have yet to give freedom to students to develop projects independently.

The front-end analysis results show that students have sufficient technology and learning environment to develop electronic teaching materials such as e-module for online learning. The needs analysis results supported these results, which showed that 78.9% of students needed e-module as teaching materials and 94.7% of students were interested in e-module based on the results of kombucha fermentation and its antibacterial activity research. The results of this analysis became the background for the researcher to develop a PjBL food microbiology e-module based on the results of research on fermentation and antibacterial activity of kombucha so that interactive learning continues even though it is carried out online and can study material independently, experiment freely, and practice 21<sup>st</sup> century skills.

### Design

The design phase results are compiling a schedule of activities to be carried out from October 2021 to May 2022, dividing project team tasks, compiling media specifications, learning content structures, and control configurations. The e-module was developed with the help of Microsoft Word 2019 and Canva application. The design of e-module components was prepared following the e-module provisions according to the 2017 Ministry of Education and Culture. The content components of the e-

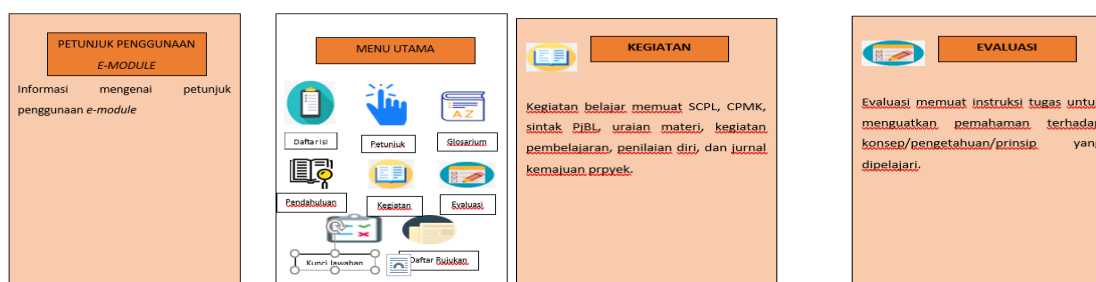
module are shown in table 2. At the content structure stage, fermentation research was carried out and tested the antibacterial activity of kombucha as e-module material. The study was conducted using single factor completely randomized design. Kombucha fermentation with different types of substrates, namely black tea, coconut water, and rosella flower, was carried out with a fermentation time of 14 days and then tested for its antibacterial activity using *Bacillus cereus* and *Escherichia coli* as the bacterial test. In the control configuration sub-stage, the researcher chose Flip PDF as the e-module format because it can be operated on various electronic devices and can contain images, videos, and animators.

**Table 2. Component of E-module**

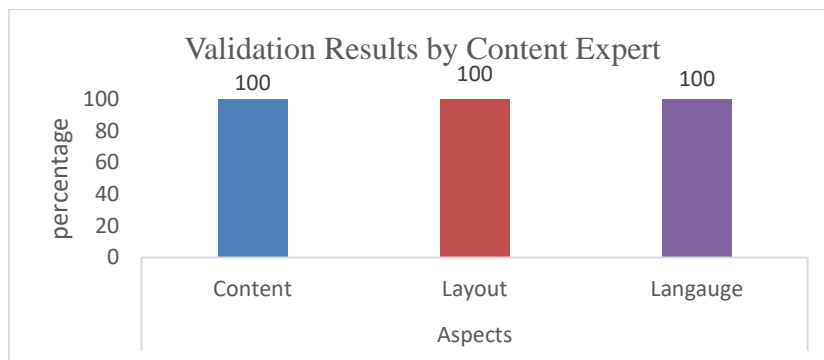
Component	Content
<b>Cover</b>	e-module title Course Introduction Course Material Educational Level Writer
<b>Table of Contents</b>	
<b>Introduction</b>	SCPL and CPMK Short description of the topic E-module instructions
<b>Learning Activity</b>	<b>Learning Activities 1</b> Aim Material description Project progress journal <b>Learning activities 2</b> and so on, according to the number of learning activities.
<b>Evaluation</b>	Test Scoring guideline
<b>Glossary</b>	
<b>References</b>	

### Development

At the development stage, the e-module design that has been compiled is then developed into a product that is ready to be tested. The development stage consists of creating storyboards, interface design, and revisions. The results of the preparation of the storyboard e-module consist of the main menu, instructions for use for lecturers and students, materials, learning activities, summary, pre-test, and post-test. The storyboard e-module is shown in Figure 1. A food microbiology material expert then validated the developed e-module. The material expert considered that the developed e-module is very valid and can be used without revision with a percentage value of 100%. The results of validation by the material expert are shown in Figure 2. The notes for improvement the material validation expert provided were to clarify several new terms and correct typing errors.

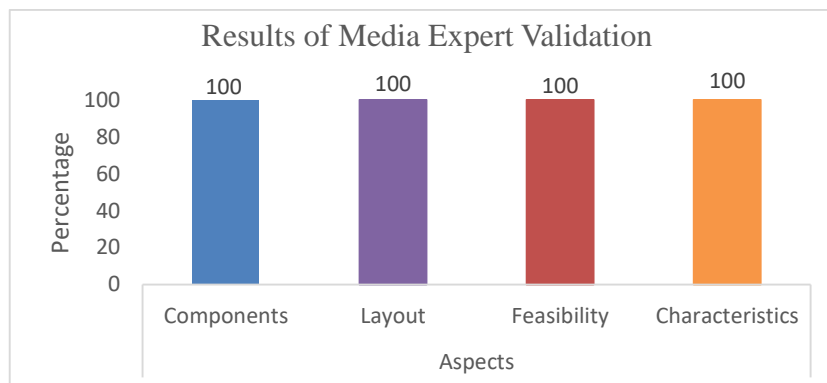


**Figure 1. E-module Storyboard**  
Source: Personal Document, (2022)



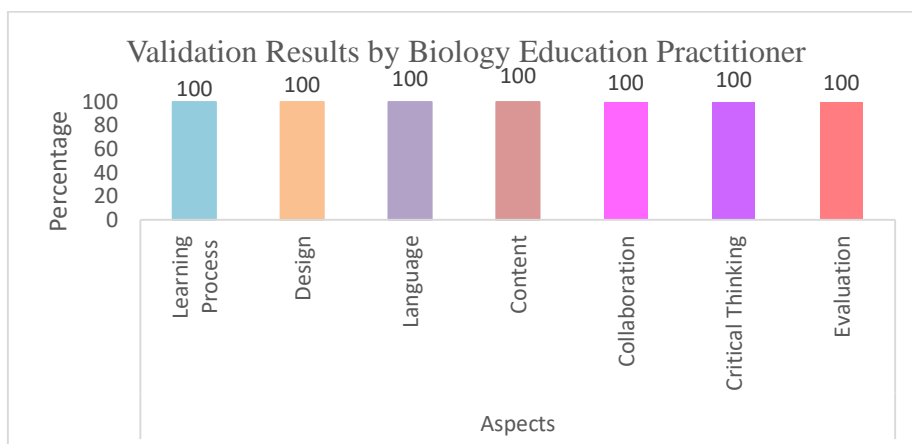
**Figure 2. Diagram of The Material Expert Validation Results**

The validation results of media expert provide a validation of value 100%, which indicates that the e-module is very valid and can be used without revision. The media expert validation results are shown in Figure 3. The advice from media expert is to increase the font size of the e-module title on the cover page, reduce the font size for the subtitle on the cover page, and place the glossary page before the evaluation activity page.



**Figure 3. Media Expert Validation Results Diagram**

Biology education practitioners give a validation value of 100%, indicating that the e-module is very valid and can be used without revision. The validation results of biology education practitioner are shown in Figure 4. The results of the individual trials given to 3 people revealed an average value of 92.44% which can be concluded that the e-module can be used without revision. In individual trials, suggestions and comments were given related to typing errors, using different fonts, and incorrect hyperlinks on the main menu. Through these suggestions, the researcher corrected typing errors, font types, and hyperlinks on the main menu before testing them in small group.



**Figure 4. Diagram of Biology Education Practitioner Validation Test Results**

The practicality test results in a small group of 9 students showed an average value of 90.96%, meaning the e-module can be used without revision. The suggestions and comments were given related to the quality of the images in the e-module, error spacing, and error spacing between images. Thus, the e-module is revised in advance to be tested on large groups.

The results of the practicality test in the large group of 20 students obtained an average score of 92.67% so that it can be used without revision. Suggestions and comments were given by respondents related to unclear image quality and writing errors. Based on suggestions and comments, researchers revised the images displayed in the e-module and corrected writing errors.

## DISCUSSION

The product being developed is an electronic teaching material in the form of a PjBL e-module based on the results of kombucha fermentation and its antibacterial activities research. E-module can help learning become more exciting and interactive (Prasetya, 2021). The needs analysis results show that the available teaching materials have not utilized technology optimally, so learning becomes less interactive. The teaching materials are power points, textbooks, scientific articles, modules, and YouTube videos. The results of front-end analysis show that the students have facilities and infrastructure that support lectures by utilizing technology. Using e-module as teaching materials can improve critical thinking skills (Seruni *et al.*, 2020) and cognitive learning outcomes (Silalahi, 2020; Rahmawati *et al.*, 2021).

The analysis results show that the teaching materials developed from the research results have not been used. Teaching materials in e-module developed based on research results can create more contextual learning. Using teaching material based on research results that present and obtain information through direct observation can provide an authentic experience to students (Habibi *et al.*, 2016). Using research results as teaching materials can make learning more effective because the material prepared is more relevant and follows academic developments (Rahmatika *et al.*, 2020).

Teaching materials such as e-module can help implement learning models more effectively. The needs analysis results show that food microbiology lectures are carried out through lectures, discussions, and projects. The lecturer still determines project activities carried out by students, so students have not been given the flexibility to decide their project themes. One of the appropriate project based-learning models to implement is PjBL. PjBL as a project based-learning model during the pandemic provides opportunities for students to carry out projects with higher goals and manage projects independently (Hira & Anderson, 2021). Learning using an e-module based on PjBL is effective in the learning and psychomotor processes (Maksum & Purwanto, 2022). E-module based on PjBL can significantly improve cognitive learning outcomes (Rahayu & Sukardi, 2021). The e-module based on PjBL involves students building knowledge and skills in preparing complex tasks and products to train students' skills and expertise (Suryandari *et al.*, 2018).

The developed e-module design consists of seven parts, namely (1) cover, which consists of the e-module title, course name, level, and compiler; (2) the table of contents comprises a table of contents, a list of figures, and a list of tables; (3) introduction composed of SCPL and CPMK information and instructions for using e-module; (4) learning consists of learning activity I, which contains learning objectives, learning activities, the content of kombucha fermentation and its antibacterial activities, and a link to fill in the project progress journal. In learning activities II to VI, there is no material description. Learning activities are composed of learning objectives, activities to be carried out, and a link to fill the project progress journal. 5) the evaluation consists of a link to fill in the post-test at the end of the learning activity; (6) A glossary containing new terms and definitions; (7) A list of references containing information regarding the reference sources used to compile the contents.

The e-module that has been developed is tested for validity by content expert, teaching material, and biology education practitioner. The validation results by the content expert get an average of 100% with a value of each aspect, namely feasibility of content, presentation, and language, each getting a value of 100%. Based on Akbar's criteria, the e-module is valid and reasonable. However, there are some suggestions and comments from content expert, such as clarifying new terms and correcting typing errors.

Teaching media and material expert give an average score of 100% with the value of each aspect, component of e-module, layout, feasibility, and characteristic of e-module, each getting a value of 100%. These results show that the e-module is very valid and reasonable to use. Suggestions from teaching media and material experts are to increase the font size of the e-module title, reduce the font size of the subtitle, and put the glossary before the evaluation activity. Biology education practitioner experts give the value of 100%. Each aspect, suitability with learning, e-module design, language feasibility, e-module material, collaboration skills, and critical thinking skills, each getting value of 100%. These results show that the e-module is very valid and reasonable to use. Suggestions from expert are to change the font colour in learning objectives.

The e-module was tested on individual, small-group, and large-group trials. The test results on individual tests get an average value of 92.44%, indicating that e-module is very practical for students. Students in the individual test gave a well-developed and very complete response to the e-module. Respondents' suggestions were to correct typing errors and fix the layouts on several pages. The test results in the small group of 8 students obtained an average of 90.96%, meaning that the e-module is very practical. Students in small group trials gave the impression that the e-module that had been developed helped the students understand kombucha fermentation content and informative material, and the layout was attractive. The large-group test was given to 20 students with an average score of 92.67% which showed that the e-module is very practical. The response given by students was in the form of an e-module containing new and complete information about kombucha fermentation. Based on the

validation, trials, and revisions made, it can be concluded that the PjBL food microbiology e-module has met practical standards, namely very valid and practical, so that it can be used in implementation activities.

### CONCLUSION

Based on research and development that has been carried out, a PjBL food microbiology e-module is developed based on the results research of the kombucha fermentation and its antibacterial activity which meets the criteria of validity, practicality, and suitability for use as teaching material with the results of validity of material expert, media and teaching material expert, and biology education practitioner respectively by 100%. The results of individual, small group, and large group trials were respectively 92,44%, 90,96%, dan 92,67%.

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