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Development of Microbiology Module "Antibacterial Effect of Ginger Rhizome Extract to Inhibit the Growth of *Propionibacterium acnes* Bacteria" as a Teaching Material to Improve Students' Problem Solving Skill

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ABSTRACT
This research is a research and development of module on the topic "Antibacterial Effect of Ginger Rhizome Extract to Inhibit the Growth of *P. acnes* Bacteria" as a teaching material in the learning process to improve students' problem solving skills. The aim of developing the module is to produce a valid, practical and effective teaching materials. The development of module used ADDIE model. Validation of the Microbiology Module was conducted by Microbiology material expert, learning media and teaching material experts, and Microbiology learning practitioner expert. The effectiveness of Microbiology Module in improving problem solving skills can be known through pretest and posttest scores analyzed through One Way Ancova test. The research and development results show that validation scores by learning media and teaching materials experts were 99.72%, Microbiology material experts were 87.56%, biology education practitioner experts were 99.33%, student practical response results were 87.05%. The efficiency results were 0.00 < 0.05 so it proved that the use of module is effective in the learning process, it can be concluded that the Microbiology Module category as very valid, very practical and effective as teaching material, so it can be used by students in Microbiology courses especially in improving problem solving skills.

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1. INTRODUCTION

Education is becoming more important in the 21st century to provide supplies for students to innovate, mastery in technology and information, and also life skills. One of the life skills is problem solving skills. Problem solving skills are skills in identifying problems, gathering information, determining and selecting solutions and implementing these solutions to solve everyday life problems (Dorner & Funke, 2017). Problem solving skills as one of the indicators of higher order thinking skills, that are important for students life skill mastery (Ichsan et al., 2019; Akben, 2020) as a supplies for students to solve in everyday life problem and are important in everyday life (Bariyyah, 2021).

One of everyday life skill that must be possessed to become a competent students is have problem solving skills (Shieh & Chang, 2014). Problem solving skills was the capacity to get some informations, assess the conditions, identify the problems to get solutions for the learning purpose (Khoiriyah & Husamah, 2018). Improving problem solving skills is the duty and responsibility of educational practitioners to choose the right learning model in the implementation of learning to improve students' problem solving skills (Hidayati & Wagiran, 2020).

Problem solving skills will be differ from one to another student, because problem solving skills are one of the complex higher order thinking skills. Based on the results of the needs analysis for problem solving skills, it shows that the number of students who answered the question correctly was only 28% in the first option answer

and 14% in the second option answer. This proved that there is still a need to empower problem solving skills so they can solve the problems in everyday life. Students who have a low level of problem solving skills, need to take the efforts to improve their problem solving skills. The efforts to improve problem solving skills can be supported by development of teaching materials in the learning process completely with practical activities. Teaching materials prepared in learning media must be detailed and complete, so the students will take sufficient skill to support the problem solving skill.

Teaching materials are a set of learning materials used to achieve basic competencies or specified learning objectives (Lestari, 2013). Learning objectives can be achieved effectively and efficiently if we pay attention to the criteria for selecting teaching materials to be used, namely paying attention to the objectives of the learning process, student conditions, the process of delivering material, efficiency and availability to use media (Ramdhani & Muhammadiyah, 2015). The learning process which is equipped with practical activities will give students the opportunity to do it themselves, observe themselves, measure and analyze the data they obtain themselves. One of the teaching materials that can be developed is a module. The modules are arranged in a structured and interesting manner and material content, learning methods, practical instructions, and evaluation for students in meeting the expected competencies (Sirate, 2017).

Module development is expected to be a solution for students in learning in Microbiology courses. Microbiology course is one of the main courses that must be taken by Biology students at the State University of Malang. One of the topics in the Microbiology course is "Antibacterial Effect of Medicinal Plant Extracts for Inhibited the Bacterial Growth". The learning topic is complemented with practical activities using the medicinal plants extract from their environment. The materials are relatively easy to obtain because people generally can take from their environment. The use of natural materials that found from the students' environment as experimental materials has not been optimally use in the learning process (Sulistyarsi, 2017).

Ginger plant (*Zingiber officinale*) is a sort belongs to plant the *Zingiberaceae* family. In everyday life the ginger rhizomes are used as spices and in traditional medicine. Ginger can be use as antiviral, antifungal, and antibacterial (Awad & Ahmed, 2017). There are three ginger varieties in Indonesia which are classified based on their morphology, namely *Zingiber officinale var. Rubrum*, *Zingiber officinale var. Officinarum*, and *Zingiber officinale var. Amarum* (Setyawan et al, 2014). The fact of using the ginger plant is as an antibiotic to treat skin infections still examine in further study, especially for the effective concentration to inhibited the bacteria growth.

Based on the results of the needs analysis, 100% of students have doesn't know that the ginger plants have antibacterial effect to inhibit the growth of the *P. acnes* bacteria. Learning the topic "Antibacterial Effect of Medicinal Plant Extracts for Inhibited Bacterial Growth" needs to be provided with effective teaching materials such as the development of a Microbiology module. Based on the results of the needs analysis, it shows that 100% of students agreed a module for on "The Antibacterial Effect of Ginger Rhizome Extract on Inhibit the Growth of the *Propionibacterium acnes* Bacteria" learning to improve their problem solving skills.

2. RESEARCH METHOD

Microbiology Module development research aims to produce a product in the form of an integrated PBL (Problem Based Learning) module for Microbiology courses. Development of the Microbiology Module in the ADDIE instructional model. The ADDIE model consists of five stages, namely analysis, design, development, implementation and evaluation (Rayanto & Sugianti, 2020). The research and development subjects were undergraduate students in Biology at State University of Malang, consisting of two classes, experiment class and control class. The type of research is a quasy experiment with a pretest-posttest non-equivalent control group design (Leedy & Ormrod, 2015). The data collection instruments and data analysis techniques collected in the research and development of the Microbiology Module are qualitative data (criticism and suggestions from validators and respondents) and quantitative data (assessment score results from validators and respondents as well as pretest-posttest results). Quantitative data analysis is explained as follows. Test the validity of teaching materials experts, material experts and educational practitioners. Validation quantitative data was analyzed using the following formula.

$$\boldsymbol{V = \frac{Tse}{Tsh}\ X\ 100\%}$$

Information:
V : Validity percentage
Tse : Total score for filling out the validation questionnaire
Tsh : Maximum total score for filling out the validation questionnaire

The module validity criteria developed from validator and field practitioner assessment questionnaire data can be seen in the percentage results in Table 1.

Table 1.Module Validity Criteria

Validation Criteria (%)	Validity Level
81.00% - 100%	Very valid, or usable without correction
61.00% - 80.00%	Fairly valid, or usable but needs minor correction
41.00% - 60.00%	Invalid, or recommended not to be used because it needs major correction
21.00% - 40.00%	Invalid, can't be used
00.00% - 20.00%	Very invalid, cannot be used

(Modified from Akbar, 2013)

Data from student response questionnaires were analyzed using response percentage analysis. The calculation formula used is as follows.

$$\textbf{Respon percentage} = \frac{\textbf{number of scores obtained}}{\textbf{number of ideal scores}} \textbf{ X 100\%}$$

Criteria for the practicality of questionnaire data on student responses to the modules being developed are seen from the percentage results in Table 2.

Table 2. Module Practicality Criteria

Validation Criteria (%)	Practicality Level
81.00% - 100%	Very practical, or can be used without correction
61.00% - 80.00%	Fairly practical, or usable but needs minor correction
41.00% - 60.00%	Not practical, or recommended not to be used because it needs major correction
21.00% - 40.00%	Impractical, unusable
00.00% - 20.00%	Very impractical, unusable

(Modified from Akbar, 2013)

The Modul Effectiveness Test

Test the effectiveness of the Microbiology Module to improve students' problem solving skills using pretest and posttest scores. The value in the normality test uses the value from the Shapiro-Wilk test and the homogeneity test uses Levene's Test of Equality of Error Variance. The influence of using the Microbiology Module in the Microbiology learning process can be seen from the One Way Ancova Test scores. One Way Ancova is used to determine the effectiveness of the Microbiology Module in learning to improve students' problem solving skills to obtain results whether the Microbiology Module has an effect or not in improving students' problem solving skills. The Microbiology Module can be categorized as effective or influential if the p-value is < 0.05.

3. RESULT AND DISCUSSION

Research Results as a Source of Teaching Materials

Based on the results of the needs analysis, it is known that students need teaching materials that are sourced from research results and contain contextual material based on problems in everyday life. This can be seen from the results of questionnaires and interviews with lecturers was obtained information that students have difficulty understanding the concept of the antibacterial activity of medicinal plant extracts, so that it had an impact on students' problem solving skills on the learning topic "Antibacterial Effect" to be understood and applied in everyday life day. These problems are in appropriate with the results of a student needs analysis questionnaire where 84% of students answered that the use of research results as a solution to contextual problems in everyday life is important to use in Microbiology teaching materials. The product developed based on the results of the needs analysis in Microbiology Module equipped with research results on problems in daily life that are valid, practical and effective. Microbiology development products are used to improve students' problem solving skills.

The Learning Models and Learning Tools Design

The purpose of the design stage is to design a learning model and learning tools for Biology students at the State University of Malang in the Microbiology course. In addition, the design stage is also carried out to design

teaching materials in the form of modules from the beginning to the end of the module to improve students' problem solving skills. The module is designed to improve problem solving skills that students face in everyday life. In connection with this, the module is equipped with practical instructions.

Module Development Based on the ADDIE Model

At the development stage, the design of teaching materials that was previously prepared will begin to be developed. This development stage also carried out product validation which aims to produce teaching material products that are valid, practical and effective in the learning process. Validation was carried out by several experts including validation by teaching materials experts, validation by Microbiology material experts, and validation by education practitioner experts. The results of the validation of the Microbiology Module by media and teaching materials experts can be seen in Table 3. The validity criteria by teaching materials experts are very valid with a percentage of 99.72%.

Table 3. Results of Module Validation by Teaching Materials and Learning Tools Experts

No.	Indicator	Average	Percentage (%)	Category
1.	Eligibility of content	5	100	Very valid
2.	Module Cover Design (Cover)	5	100	Very valid
3.	Module Content Design	5	100	Very valid
4.	Self Instructional	5	97.2	Very valid
5.	Self Contained	5	100	Very valid
6.	Stand Alone	5	100	Very valid
7.	Adaptive	5	100	Very valid
8.	User Friendly	5	100	Very valid
9.	Language Eligibility	5	100	Very valid
10.	Module Integration with Dependent Variables	5	100	Very valid
Average percentage of validation results (%)			**99.72**	**Very valid**

The development of the Microbiology Module uses the ADDIE stage development design model, namely analyze, design, develop, implement and evaluate (Branch, 2009). The developed Microbiology module was validated by teaching materials experts, Microbiology material experts, and Microbiology learning practitioners through validation questionnaires. The quality of modules as teaching materials can be measured through the results of the criteria for validity, practicality and effectiveness (Kristanto et al., 2016). The validation test aims to produce good and relevant teaching materials (Akbar, 2013). In addition, feedback and suggestions obtained during validation can be used to conduct formative evaluations before the implementation stage is carried out (Rayanto & Sugianti, 2020).

The validity test has been carried out by teaching materials experts by obtaining an average percentage of validation results of 99.72% showing a very valid category according to (Akbar, 2013) after going through a revision process. The Microbiology Module were validated by teaching materials experts the Microbiology Module used as a teaching material in the learning process for Microbiology courses (Habibi et al., 2016). In addition, the validation test aims to produce teaching materials in the form of relevant Microbiology Modules based on several assessment aspects (Akbar, 2013). The aspects assessed for validation of the Microbiology Module by experts in teaching materials and learning tools include: appropriateness of the module content, presentation and appearance of the module, practicality of using the module, language used in the module, suitability to the characteristics of the module, and integration of the module with the dependent variable. The Microbiology module is very valid in category for use as teaching material in the learning process because complete with all aspects of the assessment criteria.

The developed Microbiology module has fulfilled the module writing structure which aims to make it easier for students to study the material, achieve learning objectives and certain competencies (Rahmi et al., 2021). The module writing structure is integrated with the Problem Based Learning (PBL) module which aims to teach the material "Antibacterial Effect of Medicinal Plant Extracts" to improve problem solving skills in the learning process. Based on the characteristics of the module, namely self instructional, self contained, stand alone, adaptive and user friendly (Muldiyana et al., 2018). The Microbiology module meets the characteristics of a module that can be used in the learning process for Microbiology courses.

The validation results of the Microbiology Module by material experts were shown in Table 4. The validation criteria by Microbiology material experts are very valid with a percentage of 87.56%.

Table 4. Microbiology Module Validation by Material Experts Result

No.	Indicator	Average	Percentage (%)	Category
1.	Description of material with CPMK and Sub CPMK	4.3	86	Very valid
2.	Material accuracy	4.4	88	Very valid
3.	Breadth of material	4.4	88	Very valid
4.	Update of material	5	100	Very Valid
5.	Encourage student curiosity	4	80	Valid
6.	Presentation technique	4.5	90	Very valid
7.	Presentation support	4.3	86	Very valid
8.	Presentation of learning	4	80	Valid
9.	Coherence and consistency of thought flow	4.5	90	Very valid
Average percentage of validation results (%)			**87.56**	**Very valid**

The validity test was carried out by a Microbiology material expert to obtain an average percentage of validation results of 87.56% which is classified as very valid according to Akbar (2013) after going through a revision process. Validation of the Microbiology Module by Microbiology material experts is important in order to determine the feasibility level of the Microbiology Module to be applied in the learning process (Nesri et al., 2020). In addition, the validation test aims to produce good and relevant teaching materials in the learning process (Akbar, 2013). Aspects assessed by Microbiology material expert validators, namely aspects of material description based on the learning purposes, material accuracy, breadth of material, up-to-date material, aspects of encouraging student curiosity, presentation techniques, presentation support, learning presentation, and coherence and sequence of thought flow. The validation results by teaching materials experts show that the Microbiology Module is classified as very valid because it already completely with all aspects of the assessment criteria.

Module validity testing has also been carried out by expert Microbiology learning practitioners can be seen in Table 5. Validation criteria by Microbiology learning practitioner experts obtained an average percentage of validation results of 99.33% which is classified in the very valid category according to Akbar (2013).

Table 5. Module Validation Results by Microbiology Learning Practitioners

No.	Indicator	Average	Percentage (%)	Category
1.	Breadth of material	4.9	97.5	Very valid
2.	Clarity of presentation of material	4.9	97.8	Very valid
3.	Up-to-date material	5	100	Very valid
4.	Language eligibility	5	100	Very valid
5.	Presentation technique	5	100	Very valid
6.	Presentation support	5	100	Very valid
7.	Module usage	5	100	Very valid
Average percentage of validation results (%)			**99.33**	**Very valid**

The Microbiology Module validation by Microbiology learning practitioner's expert is important to carry out with the aim of determining the feasibility level of the Microbiology Module to be implemented in the learning process of Microbiology courses (Setambah et al., 2017). Aspects assessed by Microbiology learning practitioner's expert, consists of content completeness, material, language and presentation accuracy.

Implementation of Modules in Microbiology Learning

In the implementation stage, the validated Microbiology Module is then implemented to students. The most important thing at the implementation stage is to prepare lecturers and students. Preparation of students includes identification and observation classes, preparing implementation schedules, and technical preparations that students need during the learning process. The implementation stage was carried out directly by researchers as model lecturers using the Microbiology Module which had been developed and validated by the experts. The learning process is assisted by students and lecturers who act as observers.

The research population is all students from three offerings (Offering A, B, and H) S1 Biology Education and S1 Biology at the State University of Malang class of 2023. After conducting an equivalency test using the GPA score of semester 3 against 3 classes (Offering A, B, and H), the results of the equivalency test were obtained which stated that the three classes were equal (normal and homogeneous distributed data). The research sample was determined through random sampling technique using a spinner. The results of the spinter show that the experimental class is represented by Offering A and the control class is represented by Offering B. There were 44 students divided into 22 students from offering A students who applied learning using the Microbiology Module

integrated with the Problem Based Learning (PBL) model and 22 students from offering B who applied learning without using the Microbiology Module but using PPT with the Problem Based Learning (PBL) model. The results of the practicality test can be seen in Table 6. The practicality criteria with the results of the student questionnaire responses are very practical with a percentage of 89.90%.

The practicality test is important in order to determine the ease of using the module as teaching material by Microbiology learning practitioners and students (Annisa et al., 2020). The practicality test was also carried out through a student response questionnaire on the practicality of the Microbiology Module which contained several assessment criteria, namely: module display design, module components such as the learning purposes, content of learning material, learning activities presented, and use of the module in learning process. The results of the student response questionnaire regarding practicality show that the Microbiology Module is included in the very practical category with a percentage of 89.90%.

Table 6. Practicality Test Results of Student Responses

Respondent	Average (%)	Category
Student 1	99.23	Very valid
Student 2	89.23	Very valid
Student 3	99.23	Very valid
Student 4	78.46	Fairly valid
Student 5	81.54	Very valid
Student 6	90.77	Very valid
Student 7	96.15	Very valid
Student 8	93.85	Very valid
Student 9	90.00	Very valid
Student 10	97.69	Very valid
Student 11	80.00	Fairly valid
Student 12	100.00	Very valid
Student 13	90.77	Very valid
Student 14	84.62	Very valid
Student 15	97.69	Very valid
Student 16	78.46	Fairly valid
Student 17	80.00	Fairly valid
Student 18	85.38	Very valid
Student 19	90.77	Very valid
Student 20	90.00	Very valid
Student 21	93.85	Very valid
Student 22	90.00	Very valid
Average	**89.90**	**Very valid**

Microbiology Module Evaluation Results

The evaluation stage was conducted after the implementation process was completed. At the evaluation stage, the effectiveness of the Microbiology Module was tested to improve problem solving skills. The effectiveness test of the Microbiology Module is known through pretest and posttest scores. The pretest and posttest scores were analysed using One-Way Ancova to determine the hypothesis test, but before that a prerequisite test was carried out, namely the normality test using the Shapiro-Wilk test and the homogeneity test using Levene's Test of Equality of Error Variance. The prerequisite test results can be seen in Table 7 and the hypothesis test results can be seen in Table 8.

Table 7. Prerequisite Test Results for Problem Solving Skills Variables

Variable	Test Type		N	p	alpha	Information
Problem solving skills	Normality	Pretest	44	0.083	0.05	Normal
	Normality	Posttest	44	0.085	0.05	Normal
	Homogeneity	Posttest	44	0.591	0.05	Homogeneous

Table 8. Hypothesis Test Results for Problem Solving Skills Variables

Source	Type III Sum of Squares	df	M.S	F	p
Corrected Model	1222.605a	2	611.303	19,749	,000
Intercept	9116.095	1	9116.095	294,503	,000
PrePemMas	102.515	1	102.515	3,312	,076
Class	1160.509	1	1160.509	37,491	**,000**
Error	1269.122	41	30,954		
Total	282494,000	44			
Corrected Total	2491.727	43			

The hypothesis test result based on the One Way Ancova test proved that at a there is an significant influence of learning using the Microbiology Module on students' problem solving skills (p value 0.00 < 0.05). The use of the Microbiology Module has been proven to improve problem solving skills in students. The learning activities contained in the Microbiology Module present several sections that direct students to orientate problem to identify various solutions to solve the problems found. The learning activities in the Microbiology Module encourage students to train and improve problem solving skills. Problem solving skills have three indicators, namely identifying problems, identifying various solutions that emerge, and maintaining the right solution (Greenstein, 2012). These three indicators were proved increased on the student from the experiment group based on the results of data analysis.

4. CONCLUSION

Based on the research and development result, it was proved that the Microbiology Module that has been developed by researchers can be concluded that validation scores by learning media and teaching materials experts were 99.72%, Microbiology material experts were 87.56%, biology education practitioner experts were 99.33%, student practical response results were 87.05%. The efficiency results were 0.00 < 0.05 so it proved that the use of Microbiology Modules is effective in the learning process, it can be concluded that the Microbiology Module category as very valid, very practical and effective as teaching material, so it can be used by students in Microbiology courses especially in improving problem solving skills.

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