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Research Article

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Development of PBL-based lichens diversity e-module to improve students' problem-solving skills

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ABSTRACT

Problem-solving skills are important things everyone needs to have to improve their quality of life. The results of a needs analysis carried out on Biology students at the State University of Malang show that their problem-solving abilities are still relatively low in lichen diversity material. This research aims to determine the development of PBL-based lichens diversity e-module and its influence on students' problem-solving skills completeness e-module and its effect on students' problem-solving skills. This type of research is a development study (development research) with the ADDIE development model. This research was conducted at the State University of Malang in biology class with a sample size of 67 students. The research instrument uses problem-solving pretest and posttest sheets, as well as material expert questionnaires, media expert questionnaires, and practicality questionnaires from educators who will use the e-module. Data were analyzed using Analysis of Covariance (ANCOVA). The results showed that the e-module developed was a very good product and could be used in learning Lichen material. The results of the study stated that the e-module was effective in improving problem-solving skills (sig. < 0.05). So, it can be concluded that the PBL-based e-module is effective for improving problem-solving skills in biology students of the State University of Malang.

Keywords: Biology; lichens; problem-based learning

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INTRODUCTION

Education has a significant role in improving the quality of human resources to be ready for the Society 5.0 era (Kahar et al., 2021). Furthermore, today's education requires students to take control of knowledge and technology to generate students who will become the nation's future generation. The educational goals can be achieved if educators can develop media and teaching materials in various

ways. One of the teaching materials that can be developed is teaching materials sourced from the surrounding environment (Suyitno, 2012). Teaching materials that provide cases of environmental concerns can help students learn the content more easily (Puspridayanti et al., 2018).

Teaching materials play a significant role in the implementation of learning and can improve learning effectiveness (Arsyad, 2013). The existence of contextual teaching materials is expected to support students more easily understand material related to daily life. According to Wahyuni (2021) students will accept the material more swiftly and easily if it is connected to their daily lives. Apart from being supported by adequate teaching materials, students are also required to have 4C skills, one of them sometimes known as problem solving skills (Indarta et al., 2022). Problem-solving abilities are required in daily life as well as at business (Yokhebed, 2018).

Problem solving skills can be understood as a person's initial ability to solve problems, which requires coherent, critical, and rational thinking (Memnun et al, 2012). In order to enhance the learning process in accordance with the real-world conditions, students must be able to answer numerous difficulties logically (Özgenel, 2018). This is in line with the statement Cahyani & Setyawati (2016) that problem solving skills are relevant to the real world and can be combined to solve real world problems. Research result Mellisa (2018), stated that the problem solving skills of Biology Education Study Program students were still quite low, this demonstrated that the problem-solving abilities guided to students were inadequate.

The same problem occurs with Biology students at the State University of Malang who have taken Microbiology courses. The investigation of the problem-solving abilities yielded data with an average of 47.53%, indicating that students' problem-solving skills are still relatively low. If we look specifically at it, the data shows that the problem identification indicator has a percentage of 52.78%; identifying solutions by 45.37%; and retaining the solution by 44.44%. The learning process applied by lecturers still uses conventional models in teaching and is still Student Center Learning (SCL). This is in line with opinion Maspupah et al., (2020) that the low problem-solving skills are caused by learning resources that do not yet support and the learning model is Teacher Center Learning (TCL). Moreover, the lecturers require analysis revealed that learning about Lichens was limited to PPT, and yet to teaching materials were developed based on the outcomes of Lichens' research. Lichens are epiphytic plants that grow attached to trees, soil and other substrates (Tripp et al., 2019). Lichens is an indicator of air pollution, this is because lichens are sensitive to environmental conditions (Muslim & Hasairin, 2018).

Creating educational resources in the form of the Lichens diversity e-module is one outstanding way to increase students' problem-solving skills. E-module teaching materials can assist students in grasping concepts or information, allowing them to get a deeper comprehension of the subject matter they are currently learning (Harrati et al., 2016). According to Azeiteiro et al. (2015) e-modules can be applied independently anytime and anywhere to achieve the desired capabilities. The developed e-module will be more effective if it is delivered using a constructivist learning model, such as the Problem Based Learning (PBL) model (Linda et al., 2018). The development of e-modules combined with problem-based learning is considered capable of improving students' problem-solving abilities. This problem-based e-module has several additional features such as images, animated videos and audio as well as interactive and communicative learning characteristics that help students build their knowledge (Pramana et al., 2020). Ashari & Salwah (2017), also explained that problem-based e-modules have problems that will be investigated and solved so that they can train students' problem-solving abilities. Learning that uses problem-based e-modules encourages students to think critically, increases creativity

in solving problems, and students are able to collaborate to solve problems and communicate solutions between friends (Widya et al., 2023). Based on the explanation above, the aim of this research is to develop a PBL-based Lichens diversity emodule to improve students' problem-solving skills.

RESEARCH METHODS

This research uses two types of research, namely an exploration method to obtain lichen diversity e-module content, and a development method (development research) with the ADDIE development model to produce open material media which includes analysis, design, development, implementation and evaluation. In the analysis stage, a needs analysis and initial final analysis are carried out. The design stage includes schedules, media specifications, learning structures, configuration control and review cycles. Development stages include storyboards, e-module design, content presentation, reviews, product packaging. Implementation stages include research design, location and time, data types, research instruments, and product implementation. Implementation was carried out in two classes to determine the effectiveness of using the module on students' problem-solving abilities. The final stage, namely evaluation, includes reaction, knowledge, performance and impact.

The subjects of this research are Biology Students from the State University of Malang class of 2020. This research used a population of biology students at the State University of Malang. The sample used was 65 students in State University of Malang which consists of experimental and control classes. Data collection techniques were carried out by administering validation assessment questionnaires and measuring students' problem-solving abilities through pretest and posttest. The instruments used are module validation questionnaire sheets and problem-solving ability test questions. There are two types of data analysis techniques, namely (1) the results of the validity analysis are obtained by calculating the practicality assessment score of the e-module using the formula below then adjusted to the criteria in Table 1, and (2) using the help of anacova to determine the effectiveness of the module in solving problems.

$$V=\frac{JS}{JM}\ X\ 100\%$$

Information:

V : Validity level

JS : Total score obtained

JM : Maximum total score

Table 1. Criteria for Validity Value

Percentage Value	Criteria	Conclusion
85.01%-100.00%	Very good product	Products can be used without the need for revision
70.01%-85.00%	Good product	The product can be used with minor revisions
50.01%-70.00%	Product not enough good	Products can be used with many revisions
01.00%-50.00%	Product not good	The product still needs intensive improvement

FINDING AND DISCUSSION

The first stage of the ADDIE development model is analysis. An analysis is carried out regarding the need to develop teaching materials of an e-module of Lichens diversity in the Microbiology course. Based on preliminary observations, it was discovered that students had difficulty grasping the Lichens topic. This challenge is generated by students who have never been invited to observe Lichens in their

natural habitat. Furthermore, the teaching materials for Lichens material lectures are still in PPT layout, and inadequate instructional materials have been developed based on the findings of Lichens' research. The learning achievement to be achieved is that students are able to see the morphology and anatomy of lichen fungi in their natural habitat. Students are also expected to be able to use their knowledge of lichens fungi to provide solutions for solving problems in the student environment.

Based on this, the material used in the module was obtained from the results of our data collection, divided into two places, namely Jalan Veteran and the Malang State University library area. The type of identification that we use to identify lichen fungi is divided into 3 types, namely Crustose type, Foliose type and Fruticose type which are based on the condition of the lichen fungus thallus. The results of the exploration that have been carried out are presented in Table 2.

Table 2. Observations on Lichens diversity

No	Species	Amount ∑ individual Station 1 (on the veteran's roadside)	Amount ∑individual Station 2 (in the library area of Malang State University)
1	*Parmelia ernstiae*	47	58
2	*Lepraria sp*	44	50
3	*Flavopunctelia flaventior*	56	62
4	*Ramalina farinacea*	-	35
5	*Parmotrema perlatum*	45	50
6	*Cladonia rangiferina*	-	25
7	*Flavopunctelia soredica*	25	-
8	*Parmotrema austrosinense*	35	47
9	*Flavoparmelia caperata*	54	60
10	*Lecanora thysanophora*	30	-
11	*Pertusaria pertusa*	43	54
12	*Bacidia schweinitzii*	40	53
13	*Arthonia cinnabarina*	-	27

Based on the results of Lichens found in the Malang State University Campus area, the Lichens diversity index was obtained as presented in Table 3.

Table 3. Lichens Diversity Index

No	Station	Diversity (H')	Diversity index
1	I	2.27	Moderate Diversity
2	II	2.36	Moderate Diversity

Information:
H'<1 : Low diversity
1<H'<3 : Moderate Diversity
H'> : High diversity

As shown in Table 3, both stations are in the moderate category, with details at station I near Jalan Veteran at 2.27 and station II near the Malang State University Library at 2.36. According to the opinion of Sudrajat et al. (2013) that the diversity index value of 0-1 indicates the low diversity index category. 1-3 is a medium diversity index and a diversity value of >3 indicates a high diversity index.

The e-module will be based on observations on the diversity of Lichens on the Malang State University campus. Learning activities will run optimally if supported by learning resources (Dismarianti

et al., 2020). Utilization of natural learning resources around is an alternative teaching method (Irmeilyana et al., 2020). This is expected to add insight to students regarding the diversity of Lichens that grow in their surroundings. Teaching materials that are developed directly with learning objects can make it easier for students to comprehend the material being studied and enhance students' enthusiasm to learn (Situmorang, 2016; Irwansyah et al., 2017). This study generated an e-module teaching materials with images and videos to assist in the learning of Biology students enrolled in the Microbiology course. Illustrations and draws in instructional materials may support students in understanding and remembering the subject (Aziza et al., 2022). Figure of Lichens used in the module are presented in Figure 1.

Figure 1. Identification Lichens

This design stage was carried out in November 2022. The purpose of this stage is to design a learning model and learning tools for Biology students in the Microbiology course, State University of Malang. Aside from that, this stage also carried out the design of the e-module media design, which began with designing the first part of the e-module and ended with developing the final portion of the e-module to improve the problem-solving skills of Biology students at the State University of Malang. The developed e-module design is presented in Figure 2.

The third stage of the ADDIE model is development. At this stage, the design of the teaching materials that have been prepared previously is developed. At this stage, e-module product validation is also carried out which aims to produce teaching materials that are valid and suitable for use. There are several validations carried out by several validators, including: material experts, media experts, and also practitioners. The validation results obtained are listed below.

Material validation is carried out by validators who are experts in their field. The results obtained from material expert validation are presented in Table 4. The results of the material expert validation

show that the value obtained in the material validation is 100 with a percentage of 100%, which means that the material used is Very good product. This states that the material in the e-module can be used without the need for revision.

Figure 2. E-module Design View

Table 4. Material Expert Validation

No	Indicator	Average	Percentage (%)	Category
1	Material relevance	5	100	Very good product
2	Material accuracy	5	100	Very good product
3	Serving equipment	5	100	Very good product
4	Conformity with the demands of student-centered learning	5	100	Very good product
5	Serving method	5	100	Very good product
6	Language suitability with good and correct Indonesian rules	5	100	Very good product
7	Readability and communicativeness	5	100	Very good product
	The average percentage of validation results		100	Very good product

Aspects Aspects assessed for e-module validation include technical, appearance, text, images and videos and language. Expert validation of teaching materials is carried out by validators who are experts in their field. The assessment results from media expert validators are presented in Table 5.

Table 5. Media Expert Validation Questionnaire

No	Indicator	Average	Percentage (%)	Category
1	Technical	4.3	87	Very good product
2	Appearance	5	100	Very good product
3	Text	4	80	Good product
4	Pictures and videos	4	80	Good product
5	Language	4.3	87	Very good product
	The average percentage of validation results		87	Very good product

The results of the material expert validation show that the value obtained in the material validation is a score of 87, which indicates that the media criteria used are very good product. This states that the e-module can be used without the need for revision. Biology Practitioner validation aims to find out whether overall the teaching materials and material contained are in accordance with needs in the field. The assessment results from expert practitioner validators can be seen in Table 6.

Table 6. Field Practitioner Validation Questionnaire

No	Indicator	Average	Percentage (%)	Category
1	Serving equipment	4.5	90	Very good product
2	Content eligibility	4.5	90	Very good product
3	Language Eligibility	5	100	Very good product
4	Sintaks PBL	4.5	90	Very good product
5	Evaluation	5	100	Very good product
	The average percentage of validation results		94	Very good product

The material expert validation results show that the value attained in the material validation is 94, indicating that the media criteria utilized are very good product. This indicates that the e-module can be used without the need for revision. Based on the validation results from the validators, the average value of media experts was 87%, subject matter experts were 100%, and biology practitioners were 94%. These results state that the developed media is in the very valid category and the teaching material media is ready to be implemented. The developed e-mdoule is relevant to the content of the material, as well as the cover design which includes color, layout, images which are very adequate. Even though it is already in the form of an application that follows technological developments, its validation value is still relatively low. This indicates that the device is still less effective to be applied to users. This is because the e-module that was validated does not contain learning that encourages students to solve problems. Thus, it can be concluded that to improve students' problem-solving skills, the Lichens diversity e-module based on PBL is better than using modern applications. Problem-based e-module development can improve communication, collaboration and creativity skills which support good problem-solving abilities. This is what underlies the need for problem-based e-module development (Ramadayanty et al., 2021; Hudha et al., 2017; Nia et al., 2022).

Implementation Stages, the validated e-module is then applied to the students. The important thing at this stage is preparing teachers and students. Student preparation includes class identification and observation, arranging implementation schedules, as well as technical preparations needed by students. This implementation stage was carried out directly by researchers as model lecturers using e-module media with the material used, namely Lichens. In the learning implementation process assisted

by students and supporting lecturers who act as observers. This research was conducted in March-April 2023 at Malang State University.

Implementation of the E-Module was carried out in 2 classes, namely in Offering I with 32 students and Offering G with 33 students. This e-module was developed in the form of a Google site or web-based, which can make it easier for students and lecturers to access and operate the e-module during the learning process. Google site-based teaching media can make it easier for educators and students, because it can be opened for free, so that students can study independently anywhere (Yoriska & Ristiono, 2021). The developed e-module contains learning materials, practice questions, and evaluation. Interactive E-Modules have their own charm for students, so that it will make it easier to understand learning material (Vina, 2018). The purpose of developing this teaching material is to determine the effect of the e-module on problem solving skills in students, so that at the initial and final meetings students are given a pretest and posttest.

Evaluation Stage takes place after the implementation process is carried out. At this stage students' problem-solving skills were analyzed using the *ANACOVA* test, with the condition that normality and homogeneity tests were carried out. The results of the normality and homogeneity tests are presented in Table 7.

Table 7. Normality and Homogeneity Test Results

Descriptive Statistics					
Class	Mean	Std. Deviation	N	Nilai *Asymp.Sig* (0.200)	Nilai *Levene's* Test.Sig
Eksperiment	71.61	7.442	32	0.200	.868
Control	60.61	7.224	33		

Based on the results of the normality test in Table 5, it shows that the data on problem solving skills is normally distributed. The table above shows that the value Asymp sig. (2-tailed) = 0,200>0,05 which indicates that the data is normally distributed. While the homogeneity test results in the value table with significance α = .868 ≥ 0.05 indicates that the data obtained is homogeneous. Furthermore, the data were analyzed using the *ANCOVA* test. The results of the *ANCOVA* test show that the e-module has an influence on improving problem solving skills in biology students. The results of the *ANCOVA* test are presented in Table 8.

Table 8. ANCOVA Test Results

Tests of Between-Subjects Effects					
Dependent Variable: tes akhir					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1968.544[a]	1	1968.544	36.620	.000
Intercept	284024.467	1	284024.467	5283.551	.000
Kelas	1968.544	1	1968.544	36.620	.000
Error	3386.651	63	53.756		
Total	288719.639	65			
Corrected Total	5355.195	64			
a. R Squared = .368 (Adjusted R Squared = .358)					

According to the results of hypothesis testing using covariance analysis in Table 6, the significance value of p level = 0.368 0.05 indicated that there were differences in the ability of problem-solving skills between experimental class students who were taught using the Lichens e-module material and control class (not using e-module) students who were not taught to use the e-module. This

is because students are accustomed to carrying out learning activities linked to problem solving contained in the generated e-module.

The e-module developed is quite valid in terms of several aspects, including material aspects and media aspects. The aspect of material developed in the e-module is quite valid because the material presented in the em-module is very relevant and in accordance with student needs. Relevant teaching materials support learning, so that students can know the meaning and benefits of the learning process (Yulinda et al., 2022). The material contained in the e-module is also complete and accurate and in accordance with applicable scientific rules. This is in line with the statement Nariswari (2022) that accurate material can help learners in conceptual understanding of real life. In addition, the language used in the raw and clear material, as well as the writing of scientific words has been in accordance with the systematics of writing scientific language, so that the material is easy to learn. The teaching materials developed will be easier to use if written in standard language and easy to understand (Rahima & Putra, 2022). In addition, the material in the e-module also has contextual examples related to daily activities in the student environment. Contextual learning can be integrated into teaching materials that will be a learning resource for students (Cahyani, 2022).

The next aspect is the media aspect, the assessment of the media aspect is very good product because the content of the e-module is made with consistent layout elements, so it attracts students to use it. According to Sungkono (2009) Stating that the e-module is designed according to the technical, then the user will be easier to operate the e-module. E-modules also present videos and images that can support student learning. This is in accordance with the statement Asrial, (2021) and Wahyudyawati & Amin (2021) that students are increasingly interested in learning with e-modules if the e-module contains images, videos, or animations. In addition, the appearance of the e-module is designed with a combination of colors, elements, appropriate locations, and fonts of the writing used can be read clearly. The selection of the typeface is right, as well as the use of font size and spacing is correct. Good text readability in teaching materials can make it easier for students to understand the material presented (Alfiriani, 2017).

The PBL-based e-modules developed are arranged systematically and on target to guide students to understand the real environmental problems they encounter every day. The use of e-modules to improve students' problem-solving skills through derived indicators in the form of learning objectives, material description, learning activities and evaluation. The explanation of the material in the e-module is prepared based on the results of observations of Lichens diversity in the State University of Malang Campus area, so that the material used is contextual. The use of e-modules that contain environmental problems and local potential can affect students' problem-solving skills (Damayanti et al., 2021; Putri & Aznam, 2019; Suhartiwi et al., 2019). The use of Lichens as a learning resource can contain contextual problems. Lichens can be used as an indicator of air quality in the surrounding environment, but most students do not know about it. Lichens is one of the bioindicators of air pollution, because Lichens are sensitive to the environmental conditions of their habitat (Muslim & Hasairin, 2018).

CONCLUSION

Based on the research objectives, it can be concluded that the e-module developed by product is very good from the aspect of material (100%), media (87%), and practitioner (94%), this shows that the e-module can be used in learning Microbiology courses on lichens material. Emodule development is

able to improve students' problem-solving skills in biology students of the State University of Malang (sig. < 0.05).

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