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AUGMENTED REALITY-ASSISTED PROBLEM BASED LEARNING E-MODULE TO IMPROVE PROBLEM SOLVING SKILLS

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ABSTRACT

Abstract: Problem solving skills in the field of Biology have an important role in representing problems, finding relationships, making predictions, and verifying or checking solutions. This study aims to implement augmented reality-assisted problem-based learning e-module on bioindicator materials to improve problem-solving skills. The research method used is a pre-experimental one-group pretest-posttest design involving 29 biology students at the State University of Malang for the 2020/2021 academic year. Paired T-Test results show that the significance value (p) in the pretest-posttest is 0.000 (<0.05), which means that the e-module has a significant effect on improving students' problem solving skills.

INTRODUCTION

Problem-solving abilities are a logical and systematic capacity that students use to approach challenges, generate alternative solutions, and select the best answer (Arefnasab et al., 2012). (Hoskinson et al., 2013) To help biology students become competent problem solvers, problem solving skills play a crucial role in describing problems, searching for relationships, formulating predictions, and verifying or confirming answers. Problem-solving abilities have become a national goal for learning in many nations (McGuinness, 2005) and have become the most significant skills in 21st-century society (Greiff et al., 2013; Karmana et al. al., 2019; Miswami & Nurcahyo, 2020).

Problem-solving skills are a crucial sign of academic achievement in Indonesia (Astuti et al ., 2019). In the teaching and learning process of the 21st century, the low value of problem-solving skills is a severe concern (Miswami & Nurcahyo, 2020). The majority of students who have attended Ecology courses at the State University of Malang have not optimally utilized their problem-solving skills, according to the results of a needs analysis. Gain percentage students on numerous indicators of issue solving abilities it is known that only 49% on indicators evaluate problems, 44% on indicators of presenting solutions to problem solving, and 40% on indicators of analyzing solutions to establish the best solution to problem solving.

Ecology is one of the required courses for biology students. The context of the course material in Ecology is intimately tied to environmental issues (Mursyd & Rohman, 2020). This course can be utilized in an effort to produce graduates in accordance with the Ecology course's learning outcomes. Through well-designed instruction, student problem-solving skills can be enhanced. This is backed by Dixon and Brown's (2012) assertion that problem-solving activities must be incorporated into the learning process. Developing problem-solving skills demands integrating issues into the learning process as a stimulus (Mauke et al ., 2013).

Therefore, an active and innovative learning technique is required to engage students and give them with real-world experience. In accordance with the Ecology learning achievement in which the student not only comprehends the theory, principles, and concepts of ecology, but also applies them to environmental problems using an ecological method. By employing a problem-based learning model, contextual learning is ideally suited for enhancing students' skills in response to events in their immediate environment. Through problem-based learning, lecturers (known as facilitators) present students with challenges that require discussion and solution-finding to complete the information-gathering process and produce correct and high-quality solutions (Kadir et al ., 2016).

Problem-based learning is a learning model that emphasizes problem-solving abilities, materials, and self-organization through the use of problems (Kauchak & Eggen, 2012). Problem-based learning offers actual, real-world circumstances and is a method for understanding concepts and solving difficulties (Arends, 2012). One of the objectives of problem-based learning is the development of problem-solving skills (Tan, 2003). Environmentally-focused instruction can pique students' enthusiasm in engaging in class (Yokhebed, 2012).

According to the results of an analysis of instructional materials, students mostly utilize e-books and printed books as learning resources. According to the results of the needs analysis, lecturers have never instructed students in Ecology how to use modules. To date, lecturers have employed textbooks, e-books, handouts, films, and practical manuals as instructional resources.

The findings of Li et al. (2016) indicate that learning with module-based instructional materials can yield more effective and adaptable learning outcomes. Other research indicates that learning with modules has enhanced problem-solving skills in aspiring Biology instructors, as seen by an increase in problem-solving skills in problem-solving components (Yokhebed, 2018). The results of students' problem-solving abilities alter significantly when module learning is used (Setyoko et al., 2019). Syafii and Yasin (2013) found that problem-solving-based e-module learning can improve problem-solving skills, student achievement, and student learning outcomes.

The development of ever-more-advanced technology is always followed by the creation of instructional materials. Assisted by augmented reality (AR) technology, augmented reality (AR)-enhanced teaching materials are one of the most recent and technologically advanced breakthroughs in fascinating teaching materials. Due to the COVID-19 pandemic, lectures are now being held online; therefore, students want digital instructional materials that can be accessed from anywhere. The goal of developing the augmented reality-assisted e-module was to provide users with a clear grasp of the material by presenting certain virtual objects with contextual information (Martono, 2011). Biology comprises numerous concepts and events that necessitate observation; therefore, students must observe what they study. Moreover, according to the results of the needs analysis, augmented reality technology has never been implemented in educational materials. This study seeks to determine how the implementation of an augmented reality-assisted problem-based learning e-module affects the enhancement of problem-solving skills in ecology courses.

METHOD

The pre-experimental method was chosen using *a one-group pretest-posttest design* (Leedy & Ormrod, 2016) with the design scheme in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Treatment group	Obs1	X	Obs2

(Source: Leedy & Ormrod, 2016)

Information:
X : Learning activities with *e-module*
Obs1 : *Pretest* problem solving skills using *e-module*
Obs2 : *Posttest* t solving skills using *e-module*

This research was carried out in the biology course majoring in biology at the State University of Malang in the 2020/2021 academic year and was carried out in May 2021. The population involved were biology students at the State University of Malang with the research sample being 29 students in one class who were taking ecology courses. Data collection of problem solving skills is done by giving a *pretest* before learning and *posttest* after learning is complete. The *pretest results* were used as the basis for students' problem-solving skills, while the *posttest results* were used as final scores to determine whether students' problem solving skills are improving. The instruments used for data collection included *pretest* and *posttest essay test*. The assessment of the problem-solving skills test was adjusted to the problem-solving indicators developed by Greenstein (2012) which consist of 3 indicators: (1) identifying the problem, (2) identifying several solutions, and (3) maintaining the solution.

The data obtained were in the form of *pretest* and *posttest* which were then tested for normality using *Kolmogorov-Smirnov analysis* and to test the effectiveness*, paired sample t-test was used* with a significance level of 5%. The calculation of the increase in the value of problem-solving skills is then analyzed with the N-Gain score and interpreted into the following criteria.

Table 2. Skill Improvement Criteria

Value	**Effectiveness Level**
(g) ≥ 0,7	High
0,7 > (g) ≥ 0,3	Moderate
(g) < 0,3	Low

(Source: Hake, 1998)

RESULTS

Pretest and Posttest Scores of Problem-Solving Skills

Pretest and *posttest* problem-solving skill scores were analyzed descriptively and presented in Table 3.

Table 3. Description of Pretest and Posttest Data

Test	mean	N	Std. Deviation	Std. Error Mean	drink	Maximum
Pretest	45.91	29	12.42	2.31	25.00	68.75
Posttest	75.00	29	13.26	2.46	50.00	93.75

From Table 3, it is known that the average *pretest value* is 45.90 while the *posttest average value* is 75.43. Based on Table 3, it is known that the results of the *posttest* (M=75.43; SD=13.97) were higher than the pretest (M=45.91; SD=12.42). In addition, the minimum score achieved on the *pretest* was 25 points lower (25) compared to the minimum score for the *posttest* (50). Likewise, the maximum score achieved on the *posttest* t was 20 points higher (93.75) than the maximum score of the *pretest* (68.75).

Pretest Score Results and Posttest Analysis of Problem-Solving Skills

The pretest and posttest scores were calculated to determine the level of improvement in students' problem solving skills after the implementation of the problem-based learning *e-module*. The results of the recapitulation analysis of the average N-Gain score for each problem-solving skill indicator are presented in Table 4.

Table 4. N-Gain Score Analysis Results for Each Indicator

No	Indicator	N-gain score	Information
1	*Identify the problem*	0.41	Moderate
2	*Identifies multiple solutions*	0.69	Moderate
3	*Defends solutions*	0.56	Moderate
	Average of all indicators	0.55	Moderate

According to Hake's (1999) interpretation, the average N-Gain score of all problem-solving skill indicators is in the moderate category (0.67), which means that students' problem-solving skills experienced a moderate increase after the implementation of problem-based learning *e-modules* . Furthermore, the overall results of the *pretest* and *posttest* of problem-solving skills have increased in the average value presented in Figure 1.

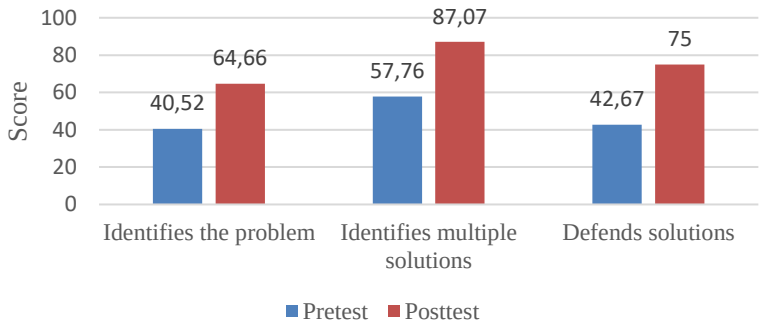

Figure 1. Pretest-Posttest Value of Problem-Solving Skills

Paired Sample T-Test Analysis Results

Although there is an increase based on the average value obtained, it is necessary to ensure its significance. Therefore, a paired sample t-test was carried out as well as a prerequisite test for normality using the Kolmogorov–Smirnov test with the following results.

Table 5. Normality Test Results

	Kolmogorof-Smirnov		
	Statistic	df	Sig.
Pretest	0.146	29	0.114
Posttest	0.144	29	0.127

Table 5 shows that the significance value (p) for the Kolmogorov-Smirnov *pretest* and *posttest* normality test is greater than the 0.05 alpha value (p>0.05). Based on the Kolmogorov-Smirnov test, the data obtained both *pretest* (0.114) and *posttest* (0.127) were normally distributed.

Table 6. Test Results Paired Sample T-Test

					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pretest-Posttest	-29.09	11.36	2.11	- 33.42	- 24.77	-13.79	28	.000

In addition, paired sample t-test was performed to ensure significant differences between the students ' pretest and posttest scores. The results of the paired t-test (Table 6) show a significance value (p) in the pretest-posttest of 0.000 (p<0.05), so H0 is rejected, which means that students' problem-solving skills have a significant effect before and after using the e-module. These results indicate that the e-module is able to improve students' problem-solving skills effectively.

DISCUSSION

This research focuses on the installation of an augmented reality -assisted problem-based learning e-module to increase students' problem-solving skills on bioindicator material. Based on the paired t-sample test, it is known that the deployment of issue-based e-module helped by AR is helpful in increasing students' problem-solving skills. In keeping with the research of Getuno et al ., (2015) that the acquisition of pretest to posttest was shown to be substantial in favor of one group being taught utilizing the e-module compared to the group being taught without the module.

Problem solving abilities are trained through the integration of problem-based learning stages in the e-module. Supported by research by Argaw et al ., (2017) reveals that problem-based learning can be more successful in strengthening problem-solving skills. The first stage is problem orientation. This level helps students to recognize information and identify problems to discover the basis and acceptable remedies. The usage of problem learning-based e-modules allows students to be more involved in identifying difficulties and finding solutions to a problem (Asmidar, 2019). (Asmidar, 2019).

The second stage is to organize students to learn. Students need to organize information to find solutions in solving difficulties. This level permits students to communicate in groups to exchange knowledge and ideas in solving difficulties. Working in groups needs students to be open to exchanging ideas and proposals that offer alternative perspectives in solving difficulties. Students can explore information freely by applying AR-assisted e-modules as mentioned by Crofton et al ., (2019), AR is highly useful for interactive and real learning media. The usage of AR can improve interest in learning since AR is interactive which helps students to see the genuine situation (Nurhasanah et al ., 2019). (Nurhasanah et al ., 2019).

The third stage is to guide investigations that require aid in carrying out investigations carried out by students. This stage trains students to obtain relevant information/data as material for formulating problem solutions. The fourth stage involves developing and presenting the work. One sort of work in studying an issue is the solution to the problem. This stage instructs students in planning and preparing the outcomes of research in the form of answers to problems uncovered in depth from diverse points of view. The availability of a point of view assists students to create a greater understanding (Arends, 2012). (Arends, 2012). At this point, students are at least able to create four feasible answers accompanied by clear explanations. Several solutions that have been collated are then picked with considerations relating to impacts/consequences, responses, and sources and effects of problems and solutions.

The fifth stage is to study and evaluate the problem-solving method. Activities to assess and evaluate the problem-solving process with solutions in the form of reflective activities to determine the effectiveness of the solutions that have been prepared. This stage contains exercises that assist students to analyze and evaluate their thinking processes as well as the intellectual and investigative abilities used (Arends, 2012). (Arends, 2012). Evaluation of issue solving is done by students through communicating problems and solutions to enhance information on problems. Overall issue-based learning activities in the application of problem-based learning enhance the development of student problem solving skills.

Several indications of problem-solving abilities define the effectiveness of the e-module on problem-solving skills. This study identifies three problem-solving indicators, including identifying the problem, discovering multiple solutions, and defending solutions (Defends solutions). The discrepancies between the pre- and post-test data on each measure of problem-solving skills are distinct and suggest an improvement. The increase in the three indications of problem-solving skills is attributable to the intensity of repeated learning, specifically three learning activities utilizing problem-based learning e-modules that contain indicators of problem-solving abilities. Using e-modules, students actively participate in the problem-solving process. Prior research demonstrates that problem-based learning is a learning model that emphasizes the development of problem-solving beliefs (Fitriani et al ., 2020). The first indicator is detecting the issue, which has an N-gain score of 0.41 and falls under the category of modest progress. At the stage of orienting

students to problems, where they examine information from phenomena to characterize a problem and add supporting details, the learning process for detecting problem indicators occurs. Every task in the e-module for examining phenomena can accommodate problem-solving skills. This is due to the fact that the process of detecting and assessing difficulties in phenomena is capable of reactivating prior knowledge through the observation of similarities between previously learned ideas and new experiences (Amar et al ., 2021). The availability of reading material greatly aids students in comprehending and analyzing the presented problems. This is reinforced by the assertion that the high score of problem-solving abilities after learning with problem-solving-based modules is due to the fact that students are able to apply reading skills and observe difficulties in the e-module (Amar et al ., 2021). When students concentrate on a subject, they may simply articulate the problem itself. Problem descriptions are necessary as a technique for simplifying and describing problems so that they are easier to comprehend (Gunawan et al ., 2020). The second indicator is the identification of several solutions with an N-Gain score of 0.69 and a category of substantial improvement. The learning process for recognizing various answers is conducted through the syntax of producing and presenting the investigation's findings. At this step, the student must provide at least four viable solutions alongside a concise description of how to solve the problem. If students are attentive, comprehend the problem, and are able to tie it to the relevant concept, it will be easier for them to create a settlement plan by giving multiple answers. The usage of e-modules for problem-based learning can assist students in tackling complicated problems since they are effective for generating ideas and problem-solving strategies. It is backed by the fact that modules that encourage group discussions and the sharing of information amongst students in a multidisciplinary problem-solving process might facilitate the development of problem-solving abilities (Srikoon et al ., 2018). The third indicator is solutions that are defended, which have an N-Gain score of 0.56 and fall into the modest improvement category. The learning process for the defends solutions indicator is also carried out during the investigation's development and presentation phases. In this indicator, students analyze and select the most appropriate and effective solution to a problem. The e-module also offers the chance to analyze and select the generated ideas. Solution evaluation is used to consider a variety of prospective problem-solving strategies. Higher order thinking skills are necessary for evaluating solutions and relating them to the proper concepts. The greater a person's capacity for evaluation, the more critical they are (Gunawan, et al., 2020).

CONCLUSION

The implementation of learning using *e-module* is effective in improving the problem-solving skills of biology students at Universitas Negeri Malang. Paired t-test results show that the significance value (p) is 0.000, smaller than the alpha value of 0.05 (<0.05), which means that the *e-module* has a significant effect on students' problem-solving skills. *E-modules* help students solve complex problems and are useful for generating ideas or problem-solving solutions. *Augmented reality*-assisted problem-based learning *e-module* can be applied to students at other universities who have the same problem and aim to improve problem-solving skills through problem-based learning. The positive impact of this research can encourage educators to imply more problem-based content in learning.

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