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Development of Human Reproductive System E-Module Based on Problem-Oriented Project-Based Learning (POPBL) to Improve Students' Concept Mastery and Critical Thinking

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ABSTRACT
This study aims to develop a teaching material in the form of an e-module on human reproductive systems that is arranged following the stages of the Problem Oriented Project Based Learning (POPBL) learning model, which is valid, practical, and effective in improving students' conceptual mastery and critical thinking skills. The research method follows the development model of Lee and Owens which was conducted on class XI MIPA students at MAN 1 Konawe. The effectiveness test was carried out using a one-group pretest-posttest design research design. The results of the data analysis based on the average conceptual mastery of the experimental group = 72.04 and in the control class = 63.22 with an ancova significance value of 0.001 and the average critical thinking skills in the experimental group = 71.54 and in the control class = 63.19 with an ancova significance value of 0.002, which indicates that the use of POPBL-based e-modules on human reproductive systems is effective in improving students' conceptual mastery and critical thinking skills.

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1. INTRODUCTION

The rapid development of technology in today's civilization, unlike in previous times, has created a constantly changing environment. This forces humans to always keep up with the times (Redhana, 2019; Fajri et al., 2021). In the 21st century, basic knowledge such as reading, writing, and arithmetic is no longer enough to compete (Nahdi, 2019). Now, 21st century skills are needed, including communication, collaboration, critical thinking, and problem-solving skills, which are often referred to as 4Cs (Aliftika et al., 2019). Therefore, educational institutions, as one of the most important entities in guiding this millennial generation, must be able to provide students with various 21st century skills. This is intended so that they can become competent individuals in facing the industrial era 4.0 (Maulidah, 2019; Hermansyah, 2020), and can play an active role in real life in the 21st century era (Fajri et al., 2021).

Critical thinking skills are one of the most important competencies for students in the 21st century era (Mardhatillah et al., 2020). Students need to have mature critical thinking skills to prepare for future jobs and overcome various problems in real life. This skill involves the ability to evaluate, understand, and analyze information from various sources to make data-driven decisions and be able to contemplate the potential outcomes and consequences of those decisions (Dulun & Lane, 2023). Critical thinking is considered a 21st century skill that allows individuals to make informed and rational decisions based on the available knowledge (O'Reilly et al., 2022). The concept of critical thinking is also closely related to the ability to connect various concepts or knowledge to reach a logical and accountable conclusion (Miele & Wigfield, 2014). This demands individuals to analyze and evaluate their thinking from different perspectives in order to improve their thinking in accordance with a specific purpose (Elder & Paul, 2005).

The importance of critical thinking skills is also related to concept mastery, where individuals with strong critical thinking skills tend to achieve better learning outcomes (Puspitawati et al., 2018). Concept mastery is the foundation for students in the process of thinking and solving problems correctly (Rodiyana et al., 2019). Science concept mastery is very important for students, because it will affect the mastery of subsequent concepts. However, several studies have shown that science concept mastery of students in Indonesia is still inadequate

(Harizah et al., 2019; Rahmah et al., 2017; Wati et al., 2018), this is evidenced by the results of the analysis of the needs of students' concept mastery tests in schools that are the object of research, which are still not optimal with an average concept mastery score of 61.65. However, 21st century skills are very dependent on understanding science concepts. Science concept mastery itself is an indicator of cognitive ability that shows students' ability to connect these concepts to reach a meaningful conclusion (Asmawati & Bintang Kejora, 2020). In the study (Eliyawati et al., 2020), it is stated that low science concept mastery can lead to a decrease in students' 21st century skills. Therefore, the challenge for a teacher is to design an appropriate learning model to improve students' science concept mastery.

The skills required to achieve the goals of education in the 21st century era include critical thinking skills. However, a number of problems have been identified in several articles related to this. Research has shown that in Indonesia, students' critical thinking skills at the secondary school level are still at a low level (Wulandari, 2018). The low critical thinking skills are also evidenced by the results of the needs analysis that has been carried out, it is known that the critical thinking score is 53.13, which indicates that critical thinking is also not optimal in the school. Some reasons for this are the lack of application of critical thinking skills in daily learning and the lack of integration of critical thinking indicators in the questions used (Annisa & Fitria, 2021; Kurniawan & Syafriani, 2021; Nurohmatin, 2017; Wijayanti & Nawawi, 2017).

The ability of concept mastery and critical thinking skills of students can be improved with various approaches that have been proven to be effective in previous research. One promising approach is to use a constructivist science learning model that supports the development of students' critical thinking skills and concept understanding. Several studies (Fakhriyah et al., 2017; Jufrida et al., 2019; Rusilowati et al., 2016) have identified that the implementation of constructivist science learning models, relevant learning resources, and appropriate evaluation tools can contribute to improving students' critical thinking skills and concept mastery.

One approach that is rooted in constructivism theory and has been proven to improve students' critical thinking skills and concept mastery is problem-based and project-based learning models, such as PBL and PJBL. In an effort to improve this approach, the Problem Oriented Project Based Learning (POPBL) learning model combines elements from both models. POPBL aims to provide a student-centered learning experience, where they are involved in projects that solve problems around them (Rongbutsri, 2017). Through this process, students are given the opportunity to think critically, collaborate in groups, and connect learning concepts to real-world situations (Moesby, 2005; Yasin & Rahman, 2011). Thus, POPBL allows the development of deep critical thinking skills and concept understanding.

The results of a teacher need analysis showed that teachers still have difficulty implementing project-based learning. These difficulties include low student motivation, student difficulty in understanding abstract material, and time constraints. To overcome these difficulties, teachers need examples of videos, devices, or project-based learning modules.

Biology learning materials, such as the Human Reproductive System, for example the process of sex cell formation, the fertilization process, embryonic and fetal development and the menstrual cycle have abstract characteristics and are difficult for students to understand. This can be a challenge in improving their understanding of these materials. To overcome this challenge, the development of interactive e-modules as learning tools is highly necessary. This E-Module is designed to support the development of students' critical thinking skills and conceptual mastery by using multimedia elements, such as sound, video, and animation. The E-Module aims to make abstract material easier to understand and more engaging for students. In addition, the E-Module's accessibility through digital devices allows students to learn anytime and anywhere, increasing their motivation and interest in learning (Dewi & Lestari, 2020; Ernawati & Susanti, 2021).

By combining the developed E-Module with the Problem Oriented Project Based Learning (POPBL) model, it is hoped that students will have a better opportunity to develop their critical thinking skills and conceptual mastery. This is because the E-Module can be integrated with the POPBL stages, which emphasize problem-solving, group discussion, and the application of concepts in real-world contexts (Rongbutsri, 2017). Therefore, this study aims to develop a POPBL-based E-Module to improve students' conceptual mastery and critical thinking.

2. RESEARCH METHOD

This study is a research and development study that follows the development model of Lee and Owen. There are five stages in this study, namely assessment and analysis, design, development, implementation, and evaluation (Lee & Owens, 2004).

This study was conducted in the second semester of the 2022/2023 academic year at MAN 1 Konawe, the research subjects were biology education practitioners, media experts, content experts, and 73 eleventh grade science students. The students were divided into two groups: 37 students from class XI IPA 1 and 36 students from class XI IPA 2. Students in class XI IPA 1 learned using the POPBL syntax and a POPBL-based e-module, while students in class XI IPA 2 learned using the PBL model and a PowerPoint-based presentation. Data collection in this study was carried out through test instruments and e-module quality questionnaire instruments.

Before this e-module was piloted, it first needed to be validated by content experts, media and language experts, and educational practitioners. Meanwhile, to see the effectiveness of using the e-module, it uses a multiple-choice and essay test instrument that has been validated and reliable against the instrument.

The data collected consists of qualitative descriptive data and quantitative descriptive data that are used to improve the product development results. Qualitative data were obtained from inputs, feedback, comments, and improvement suggestions from experts. Meanwhile, quantitative descriptive data were obtained through validation results by experts as well as practicality results from one-on-one trials, small group trials, and field trials, which were then presented in percentage form.

Implementation to measure the effectiveness of using the reproductive system e-module is carried out in a non-face-to-face situation. The data from the implementation were then analyzed and the results were translated into categories that are relevant to the measurement of product effectiveness. The effectiveness testing of the development was carried out using a one-group pretest-posttest design research design involving 24 test sheets. The effectiveness of the e-module was tested by comparing the pretest and posttest scores of students in the experimental and control classes using Ancova analysis. Ancova was chosen because it allows for the elimination of the influence of covariate variables, the comparison of groups with different sizes, and the improvement of the precision of the analysis.

3. RESULT AND DISCUSSION

The research and development that has been conducted has produced a teaching material product, in the form of a POPBL-based reproductive system e-module to support student learning in the biology subject. The results of the assessment and analysis stage showed that students and teachers at MAN 1 Konawe needed a practical, flexible, and easy-to-understand teaching material to help students learn abstract and difficult-to-see materials directly. In addition, students also needed a learning model that encourages active student involvement, such as the project-based learning model (POPBL). Furthermore, it is important to train the mastery of concepts and critical thinking in order for students to learn reproductive system material well.

In the design stage, scheduling, media specifications, content structure, and configuration control were carried out. The teaching material in the form of an E-Module that is integrated with the syntax of the POPBL model was designed using Canva, Microsoft Word, and PowerPoint, and was then published through the Heyzine platform.

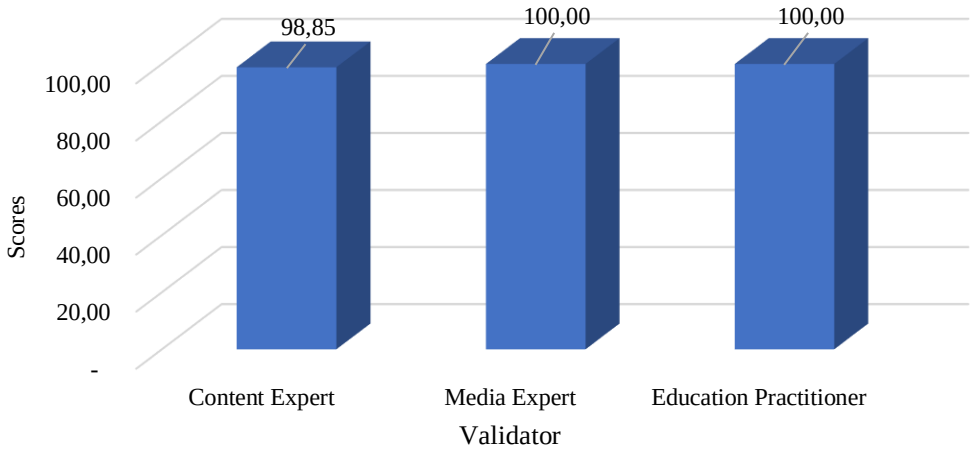

Figure 1. Validator Assessment Results

The development phase involved the creation of a prototype e-module on the reproductive system based on POPBL. The prototype was then validated by content expert, media experts, and education practitioners. The validation results in Figure 1 show that the POPBL-based reproductive system e-module has a validity level of 98.85%, 100%, and 100%, all of which are classified as very valid.

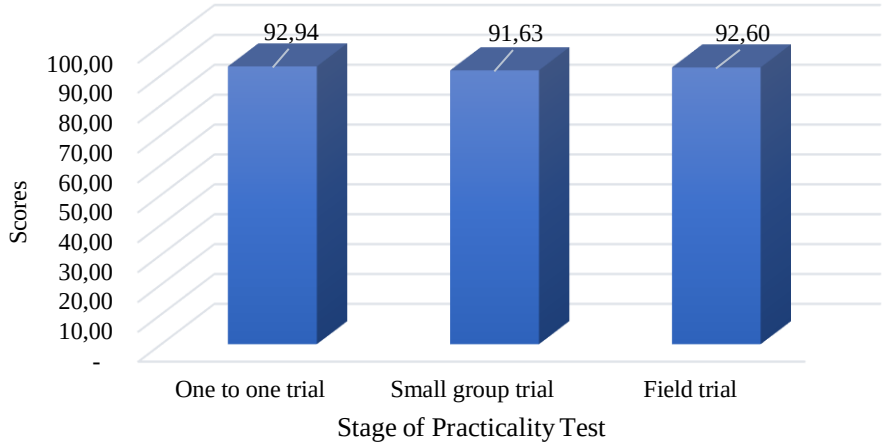

Figure 2. Practicality Test Results

Practicality trials in the form of one-on-one trials, small group trials, and field trials were conducted on students who had previously studied the reproductive system using a questionnaire to measure the practicality of POPBL-based reproductive system e-modules. The results of this practicality test which can be seen in Figure 2 showed that the POPBL-based reproductive system e-module had a practicality rate of 92.94%, 91.63%, and 92.60%, with the third category being very practical. Based on these percentage results, overall, students can use the POPBL-based reproductive system e-module that has been developed as a teaching material for the Biology subject.

Table 1. Concept Mastery Analysis Results

Group	Mean		Difference	% Increase	Adjusted Mean
	Pretest	Posttest			
Experiment	29.63	70.71	41.08	138	72.04
Control	32.08	64.58	32.50	101	63.22

Table 2. Results of Ancova Test of Reproductive System Concept Mastery

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3343.815[a]	2	1671.908	15.202	.000
Intercept	2542.606	1	2542.606	23.119	.000
Pretest_Concept_Mastery	2656.670	1	2656.670	24.156	.000
Kelas	1353.939	1	1353.939	12.311	.001
Error	7698.623	70	109.980		
Total	345554.912	73			
Corrected Total	11042.438	72			

a. *R Squared* = .303 (*Adjusted R Squared* = .283)

The results of the implementation phase were to measure the effectiveness of the POPBL-based reproductive system e-module on students' conceptual mastery and critical thinking skills. Based on the SPSS Output Value of the Ancova test of conceptual mastery with the pretest values of each experimental and control class used as a covariate, the Sig value = 0.001 was obtained, which means less than 0.05, thus there is a difference between the experimental class and the control class. Based on the results of the corrected mean analysis, the corrected mean value of students' conceptual mastery in the experimental group = 72.04 and in the control class = 63.22. This means that the increase in the value of conceptual mastery in students who received treatment using the POPBL model assisted by the POPBL-based e-module is higher than students who use the PBL model assisted by PPT, as evidenced in Table 1, the experimental class is 138% while the control class increases by 101%. Based on this data, it can be concluded that the application of the POPBL model assisted by the POPBL e-module has a significant effect on the value of students' conceptual mastery and has been proven to be effective in improving students' conceptual mastery.

Table 3. Results of Critical Thinking Analysis

Group	Mean		Difference	% Increase	Adjusted Mean
	Pretest	Posttest			
Experiment	35.81	70.64	34,83	97	71.54
Control	37.65	64.11	26,46	70	63.19

Table 4. Results of the Ancova Test of Critical Thinking in the Reproductive System

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3815.318[a]	2	1907.659	15.129	.000
Intercept	2126.619	1	2126.619	16.866	.000
Pretest_Critical_Thinking	3038.360	1	3038.360	24.096	.000
Kelas	1248.239	1	1248.239	9.899	.002
Error	8826.486	70	126.093		
Total	344530.241	73			
Corrected Total	12641.804	72			

a. *R Squared* = .302 (*Adjusted R Squared* = .282)

Based on the SPSS Output Value of the Ancova test of critical thinking skills with the pretest values of the experimental and control classes used as a covariate, the Sig value = 0.002 was obtained, which means less than 0.05. Thus, there is an effect of using the POPBL-based e-module. Based on the results of the analysis of the corrected mean values, the mean value of students' critical thinking in the experimental group = 71.54 and in the control group = 63.19. This means that the increase in the value of critical thinking skills in students who received treatment using the POPBL model assisted by the POPBL-based e-module is higher than students who use the PBL model assisted by PPT. This is evidenced in Table 3 that the experimental class had an increase of 97% while the control class increased by 70%. Based on this data, it can be concluded that the application of the POPBL model assisted by the POPBL e-module has a significant effect on the value of students' critical thinking and has been proven to be effective in improving students' critical thinking.

In the evaluation phase, formative evaluation was conducted to improve the product. The long-term plan is to improve the creation of e-modules both in terms of appearance (front end) and technical (back end), so that this e-module is suitable for widespread use by users.

The results of this study indicate that the POPBL-based reproductive system e-module that has been tested for validity and practicality has a positive impact on improving students' conceptual mastery and critical thinking skills. Based on student response questionnaires after learning, this E-module is proven effective in increasing student participation and understanding. This allows students to undergo a process of independent exploration, which can improve their understanding of the concepts taught. In addition, POPBL-based learning has a well-organized structure, which helps students to understand the relationships between complex concepts.

In addition, POPBL is a combination of the PBL and PjBL models (Eliyawati et al., 2020). The PBL model is an active learning method in which students are typically involved in a collaborative project with the goal of solving a problem (Darling-Hammond et al., 2015). In PBL, students are expected to work together in a team to overcome challenges together (Johnson et al., 2013). This approach also promotes deeper and more practical learning because it emphasizes team reflection and decision-making (Bender, 2012), which ultimately allows for the achievement of a deeper understanding of related concepts (Krajcik & Czerniak, 2018). Project-Based Learning (PjBL) is a student-centered learning model in which students work together in teams to complete complex and meaningful projects. PjBL encourages students to use higher-order thinking skills, such as critical thinking, problem-solving, and collaboration. POPBL combines the two approaches, so that students are not only required to solve problems, but also to create a product as a result of the problem-solving.

POPBL-based e-modules also present content in various multimedia formats such as videos, images, and audio, which can help students understand difficult concepts. The e-module content provides clear visual illustrations and easier-to-understand contexts. POPBL-based e-modules can be adapted to a variety of learning styles and student comprehension levels, allowing them to learn according to their individual needs. Not only that, e-modules can be accessed by students anytime and anywhere, providing flexibility in learning according to the rhythm and schedule of each student. The POPBL model also encourages students to think critically and apply concepts in real-world situations, helping them understand the relevance of those concepts.

4. CONCLUSION

Based on the results of the study and discussion, it can be concluded that the learning material in the form of a POPBL-based reproductive system e-module has been tested for validity and practicality and is effective in improving students' conceptual mastery and critical thinking skills.

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