Effectiveness of Integrated Interactive Problem Based Learning E-Modules in Improving Critical Thinking Abilities

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Abstract: This study aims to analyze the improvement of students' critical thinking skills by using interactive modules integrated with problem-based learning on the excretory system material. The research method used pra experimental research design with a One-Shot Case Study. The data collection instrument was critical thinking ability test questions analyzed using SPSS version 27 software. The results showed a significant value for the T-test of 0.000 (<0.05), with an average N-gain score of 0.63, meaning there was a significant difference. The results of critical thinking abilities before and after using the PBL integrated interactive e-module with a significant increase of 0.63 (medium). So it is concluded that the PBL integrated interactive e-module is feasible, practical, and effective for improving students' critical thinking skills in studying biology on excretory system material.

Introduction

Critical thinking is one of the advanced thinking skills that is important for skill development in the 21st century (Rahardhian 2022). Furthermore, critical thinking is defined as the process of using reason to solve problems by first understanding the problem, expressing opinions or arguments clearly, and drawing conclusions from existing problems (Juliyantika and Batubara 2022). In the learning process, critical thinking skills are very important. Students who are able to use these skills tend to be better at understanding and solving problems and are more successful in facing tests and exams (Ariadila et al. 2023). However, in reality, students' critical thinking abilities in Indonesia are still relatively low. This is proven by the results of the Program for International Student Assessment (PISA) Indonesia in 2018. PISA questions are known to be able to measure students' level of critical thinking. Of the 78 countries participating in 2018, Indonesia was ranked 72nd (Organization for Economic Co-operation and Development, 2019). Therefore, there is a need for the latest innovations in the learning process to improve students' critical thinking abilities.

One learning innovation that can be used is by utilizing digital technology in the learning process. Digital technology that is increasingly popular today is the E-module. E-modules or electronic modules are digital modules that include text, images, or both, contain digital electronic material, and are equipped with simulations that are suitable for use in learning (Herawati and Muhtadi 2018). E-modules play an important role in the learning process, namely helping teachers explain lesson material. The advantage of E-modules compared to other print media is their interactive nature. E-modules presented in digital form can be accessed via a laptop or computer (Pramana, Jampel, and Pudjawan 2020).

The current use of e-modules can be an alternative for students to study independently during learning. This is because e-modules have "self-instructional"

characteristics, which allow students to learn by themselves without depending on other people. Apart from that, e-modules are also adaptive. This means that e-modules can adapt to advances in science and technology, provide flexibility in their use, and the material presented in them remains relevant and can be applied for a predetermined period (Ernawati and Susanti 2021). According toVidianti & Qonita (2022) The application of e-modules in learning activities has demonstrated their effectiveness in facilitating independent learning, which contributes to the creation of a more supportive learning environment. This also plays a role in helping students to develop their abilities in critical thinking. Apart from teaching materials, the learning model applied also plays an important role in improving students' critical thinking abilities. Various learning models used by teachers in the educational process can enrich student competence. According to Aspini (2020), The use of innovative and creative learning models can maximize students' comfort and thinking abilities. In the 21st era, skills such as critical thinking are very important, especially in solving problems (Aryulina and Riyanto 2016).

Problem Based Learning (PBL) is an educational method that invites students to actively solve problems and develop critical thinking skills. According to Hadi, (2018) PBL requires students to identify and solve given problems. The main characteristics of PBL include an interdisciplinary approach, authentic investigation, the creation of concrete products such as reports, and collaboration. Research by Serevina et al., (2018); Retnowati et al., (2018) shows that PBL significantly improves students' science and cognitive processing abilities, as well as their learning outcomes. Therefore, PBL is considered effective in improving students' critical thinking abilities and their learning outcomes.

Research related to E-Modules integrated with problem-based learning models, namely research from Hidayanti, Supratman, and Noviati (2022) found that E-Modules integrated with PBL can improve students' science literacy compared to conventional learning classes. Research by Utari et al. (2023) stated that E-Modules integrated with Problem-based learning models can improve creative thinking skills with an N-Gain value of 0.69 in the moderate category. In addition, research by Agustia and Fauzi (2020) found that E-Modules integrated with Problem-based learning models can improve student competencies including knowledge with an N-Gain value of 0.75, including the high category.

The difference between the research conducted by the author and previous research is that the author studied the Interactive Biology E-Module Based on Flip PDF Professional assisted by Canva to improve the critical thinking skills of junior high school students. Interactive e-modules are displayed using the Flip PDF Professional application, which is Android/IOS software that can display e-modules practically. Flip PDF Professional is also the right solution because e-modules contain materials, images, and videos that can be displayed easily (Marizal and Asri 2022). The urgency of this research is the unavailability of interactive E-Modules based on professional flip PDF applications that can improve critical thinking skills. For this reason, this research aims to analyze students' critical thinking skills increase when learning using interactive e-modules integrated with problem-based learning on excretory system material.

Research Method

This study used a pra experimental research design in the form of a One-Shot Case Study. This research was conducted at SMAN 1 Muaro Jambi with a research sample of class XI 1 students totalling 22 students. The instrument used in this research was a critical

thinking ability test consisting of 10 questions. The test used consists of a pretest and a post-test. This test was designed in the form of open-ended questions, which allows students to freely express their ideas or answers to the questions given, so they can train their critical thinking skills. The questions given were based on indicators of critical thinking abilities according to Facione (2011) which include six indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The grid of the test instruments used is as follows:

Table 1. Critical Thinking Ability Test Grid

Aspects of Critical Thinking	Critical Thinking Indicators	Question Number	Number of Questions	Cognitive Level
Provide a simple explanation (elementary clarification)	Analyzing arguments	1, 2	2	C4, C4
Building basic skills (basic support)	Considering the results of observations	3, 4	2	C5, C4
Concluding (inference)	Make deductions and consider the results of the deduction	5, 6	2	C4, C5
Provide further explanation (clarification)	Identify terms and consider	7	1	C4
	Identify assumptions	8	1	C4
Strategy and tactics (strategic and tactics)	Determining an action	9, 10	2	C4, C4

The data analysis technique used is the t-test to see differences in values *pretest and post-test* after using the module and the N-gain test which aims to find out how much students' critical thinking abilities have increased based on pretest and post-test scores.
The normalized N-gain analysis formula according to Hake (1998) is as follows:

$$Ngain = \frac{Skor\ Postest - Skor\ Pretest}{Skor\ maksimum - Skor\ Pretest}$$

The results of the N-gain calculations are then interpreted using the N-gain interpretation in Table 2 below:

Table 2 Interpretation of Ngain

The size of Ngain	Interpretation
$g > 0.7$	Tall
$0.3 \leq g \leq 0.7$	Currently
$g < 0.3$	Low

Source: Hake (1998)

Results and Discussion

At the first meeting, the researcher started the lesson by greeting, praying, introducing himself, checking students' attendance, and explaining the learning objectives. Then, the researcher gave a pretest to students. After the pretest was completed, the e-module was shared via WhatsApp for students to study independently. After studying the e-module, students hold group discussions to work on the worksheets in the e-module, with students divided into 5-6 groups.

At the second meeting, students studied the e-module independently. Then, discussion activities were carried out to work on the worksheets contained in the e-module. At the end of the learning session, a post test was carried out to measure the results after studying the e-module. After implementing the media in the learning process, the next step is to process the implementation data which includes pretest and post test data to assess the effectiveness of the media used in learning on students' critical thinking abilities. Pretest and post test data

processing was carried out using Microsoft Excel and SPSS 27. Data was processed using the paired sample T-test and N-gain test. Paired sample T-test is a method of testing paired data on the same individual with two different treatments to determine the differences. The N-gain test is used to measure the increase in students' critical thinking abilities. The results of the assessment of students' critical thinking ability indicators are presented in Table 3 below.

Table 3. Results of Assessment of Students' Critical Thinking Ability Indicators

Indicators of Critical Thinking Ability	*Pretest*		*Posttest*	
	Average	Percentage	Average	Percentage
Provide a simple explanation (elementary clarification)	51	51%	67.5	67.5%
Building basic skills (basic support)	57.5	57.5%	72	72%
Concluding (inference)	54.5	54.5%	82.5	82.5%
Provide further explanation (clarification)	63.5	63.5%	87	87%
Set strategy and tactics (strategic and tactics)	51.5	51.5%	69	69%
Amount		**278**		**378**
Average		**55.6**		**75.6**

Based on the average results of each indicator of students' critical thinking abilities, the aspect that has the highest percentage in the pretest and post-test is the indicator of providing further explanation (clarification) with a percentage of 63.5% in the pretest and 87% in the post-test. Indicators that have a low percentage are indicators that provide simple explanations (elementary clarification) with a percentage of 51% in the pretest and 67.5% in the post-test, as well as managing strategies and tactics (strategic and tactics) with a percentage of 51.5% in pretest and 69% on the post-test. The percentage of students' critical thinking ability assessment results is presented in Figure 1 below.
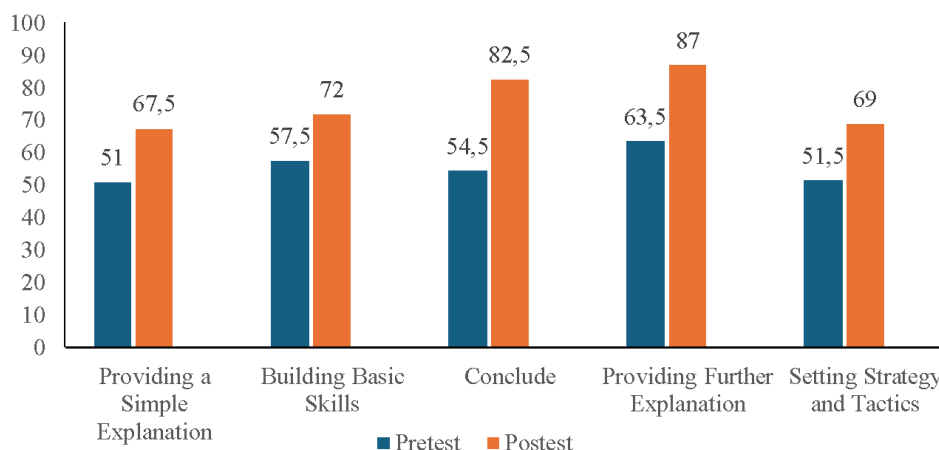

Figure 1. Results of the assessment of aspects of students' critical thinking abilities

These results show that there are quite a few students who still do not understand the role of the excretory system in maintaining the health of the human body and the impact of the dysfunction of the excretory system. Apart from that, in the indicator of managing strategies and tactics (strategic and tactics) there are still many students who cannot fully explain the process of urine formation based on the pictures provided and cannot fully explain how air quality can influence the lung excretion process and its effects to health.

The results of the pre-test and post-test scores, before the paired sample T-test is carried out, a normality test is first carried out to determine whether the data is normally distributed or not as one of the conditions for carrying out the paired sample T-test analysis test. Data from the pretest and posttest normality test results are presented in Table 4 below.

Table 4. Data Normality Test Results Pretest And Posttest

	Tests of Normality					
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	Df	Sig.	Statistics	df	Sig.
Pretest	,139	22	,200*	,922	2	,084
Posttest	,145	22	,200*	,935	22	,159

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 4 shows the results of the data normality test using the method *Shapiro Wilk,* based on the results obtained, it shows a significance value *pretest* And *posttest* respectively 0.084 and 0.159 which indicates that the data is normally distributed due to the significance value pretest And posttest is greater than 0.05 (P>0.05). This is in line with the statement of Aritonang, Siagian, and Pasaribu (2023) which states that if the significance value is greater than 0.05 at (p>0.05) then the data is said to be normal, conversely if the significance value is smaller than 0.05 at (p <0.05) then the data is said to be abnormal. Test prerequisites are met, then the test is carried outpaired sample T-test. Results from the test paired sample T-test are presented in Table 5 below.

Table 5. Test Results Paired Sample Statistics

		Paired Samples Statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	63.3636	22	13.20730	2.81581
	Posttest	86.1818	22	8.77570	1.87099

Based on table 5, it is known that the average value *pretest* is 63.36 and the average value post-test is 86.18. So, the average score after being given treatment is higher than before being given treatment. This shows that there has been an increase in critical thinking skills in using media in learning. Test results paired sample T-test can be seen in Table 6 below.

Table 6. Test Results Paired Sample T-test

		Paired Samples Test							
			Paired Differences				t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-22.81	9.10	1.94	-26.85	-18.78	-,75	21	,000

Based on Table 6, it is known that the significance value is 0.000 (<0.05). This shows that there is a significant difference between before and after using the media. Next, analysis is carried out N-gain to determine the level of improvement that has occurred. Score results N-gain can be seen in Table 7 below.

Table 7. Value Results Pretest and Posttest (N-gainscore)

Respondent	*Pretest*	*Posttest*	*N-gain score*	Category
AYP	65	75	0.29	Low
A.M	40	78	0.63	Currently
CBC	53	85	0.68	Currently

DA	78	98	0.91	Tall
EAP	80	93	0.65	Currently
IGM	70	85	0.50	Currently
IO	55	83	0.62	Currently
JS	43	70	0.47	Currently
JU	60	83	0.58	Currently
CASH	50	73	0.46	Currently
LFN	80	95	0.75	Tall
M.F.A	75	98	0.92	Tall
M.S	65	88	0.66	Currently
MAS	80	95	0.75	Tall
N	73	85	0.44	Currently
NA	45	73	0.51	Currently
PSRD	60	93	0.83	Tall
RDBA	78	95	0.77	Tall
RNFE	78	85	0.32	Currently
S	58	98	0.95	Tall
S	50	80	0.60	Currently
TA	58	88	0.71	Tall
Average	**63**	**86**	**0.63**	**Currently**

Based on Table 7, there was an increase in students' critical thinking skills of 0.63 (medium category). This means that there is an influence of e-module media on students' critical thinking abilities with a moderate level of effectiveness. This is in line with research conducted by Peprizal and Syah (2020) which states that the learning media that has been developed can be said to be effective if the N-Gain score is at least in the medium category. Apart from that, research conducted by Puspita and Aloysius (2019) shows that the problem-based learning method is effective in developing students' critical thinking skills, as evidenced by an increase in the N-Gain score, significance value on the T-test, and an increase in the percentage of thinking ability test results critical of students.

The distribution of students' levels of achievement of critical thinking skills can be seen in Figure 2 below.
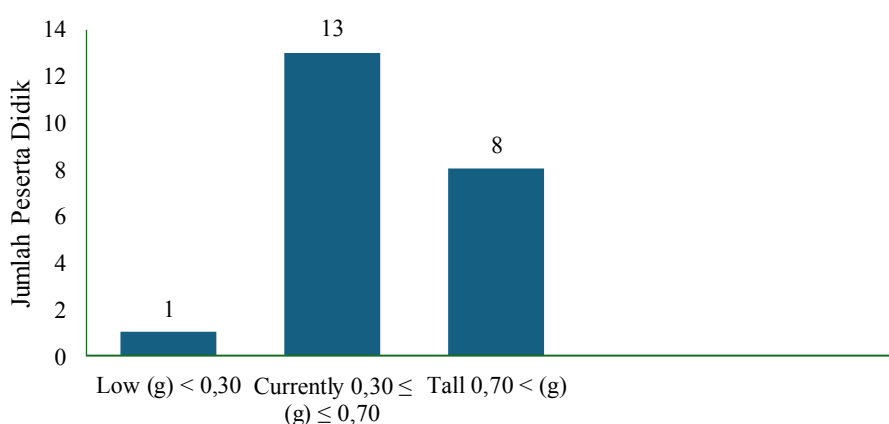

Figure 2. Distribution graph of students' critical thinking ability achievement levels

Based on Figure 2, it can be concluded that of the 22 students, 8 students had a high N-gain category, 13 students had an N-gab score in the medium category and 1 student had a low N-gain score.

The results of the N-Gain score obtained are in the medium category, and it can be concluded that the interactive e-module integrated with problem-based learning (PBL) is

effectively used in learning. This is supported by research by Anesa and Ahda, (2021) which states that the use of PBL-based e-modules has the effect of improving students' critical thinking abilities. This is because PBL can develop students' critical thinking skills, and problem-solving abilities and build their knowledge. Apart from that, according to Islahiyah, Pujiastuti, and Mutaqin, (2021), the PBL module makes students focus on problems and look for alternative solutions to solve them.

PBL-based e-modules encourage active learning where students are directly involved in the learning process. They not only receive information passively but also must apply their knowledge in solving problems. In PBL, students often must go through a continuous evaluation process where they receive feedback from teachers and peers. This feedback helps students continue to improve and develop their critical thinking skills (Janna, Yovita, and Vebrianto 2023). The advantages of the PBL model are that it increases understanding, independence, and high-level thinking skills, increases motivation, and improves skills in building teamwork (Pramana et al. 2020). The results of this study support the integration of PBL-based e-modules in the education curriculum. Thus, schools can consider adopting this method more widely to improve students' critical thinking skills. In addition, this study emphasizes the importance of using technology in learning. PBL-based e-modules can be one solution to face the challenges of education in the digital era, especially in improving 21st-century skills such as critical thinking.

Conclusion

Based on the results obtained, it is concluded that the significant value for the T-test is 0.000 (<0.05), with an average N-gain score of 0.63, meaning that there is a significant difference in the results of critical thinking skills before and after using the integrated interactive e-module PBL with a significant increase of 0.63 (moderate). So it is concluded that the integrated interactive e-module PBL is declared feasible, practical, and effective in improving students' critical thinking skills in studying biology on the excretory system material.

Recommendation

Based on the results of the development research, several recommendations can be followed up as follows: (1) for teachers, they should conduct periodic evaluations of the effectiveness of the e-module, and ask for feedback from students to continue to improve and adjust the module according to student needs. (2) for students, they must be actively involved in the learning process using PBL-based e-modules. Students must participate in discussions, collaborations, and problem-solving provided in the module. (3) for researchers, to conduct further research to explore the effectiveness of PBL-based e-modules in various educational contexts and subjects.

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