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Improving Students' Critical Thinking Skills Using the Problem-Based Learning Model Assisted by Virtual Laboratories

Yulia Ramdinawati Syam[1*], Surti Kurniasih[2], Rita Retnowati[3]

[1] Department of Science Education, School of Postgraduate, Pakuan University, Bogor, Indonesia
[2,3] Islamic Senior High School 4 Bogor, Indonesia.

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ABSTRAK

Keterampilan berpikir kritis siswa saat ini cenderung masih berada pada kategori rendah. Hal ini menyebabkan perlunya inovasi dalam metode dan model pembelajaran yang dapat meningkatkan keterampilan berpikir siswa. Penelitian ini bertujuan untuk mengetahui peningkatan keterampilan berpikir kritis siswa melalui model pembelajaran problem-based learning (PBL) berbantuan laboratorium virtual pada proses pembelajaran Biologi. Penelitian ini menggunakan metode pre-eksperimen dengan desain one group pretest postest design. Subjek penelitian terdiri dari 30 siswa kelas XI Sekolah Menengah Atas. Metode pengumpulan data berupa observasi, tes essay keterampilan berpikir kritis dan kuesioner respon siswa. Instrumen pengumpulan data menggunakan kuesioner dan soal tes. Uji validitas empiris instrumen menggunaan korelasi pearson product moment pada SPSS dan Alpha Cronbach untuk uji reliabilitasnya. Analisis data mengguna kan Uji N-Gain untuk masing -masing indikator keterampilan berpikir kritis. Hasil uji N-Gain menunjukkan bahwa penerapan model pembelajaran PBL berbantuan laboratorium virtual signifikan meningkatkan rata-rata keterampilan berpikir kritis dengan kategori tinggi. Dengan demikian, maka disimpulkan bahwa terjadi peningkatan keterampilan berpikir kritis siswa melalui proses pembelajaran dengan model pembelajaran PBL berbantu laboratorium virtual

ABSTRACT

Students' critical thinking skills currently are in the low category. It causes the need for innovation in learning methods and models that can improve students' thinking skills. This research aims to determine the improvement of students' critical thinking skills through the problem-based learning (PBL) learning model assisted by a virtual laboratory in the Biology learning process. This research uses a pre-experimental method with a one-group pretest post-test design. The research subjects consisted of 30 eleventh-grade high school students. Data collection methods include observation, critical thinking skills essay tests, and student response questionnaires. Data collection instruments use questionnaires and test questions. Test the empirical validity of the instrument using Pearson product-moment correlation in SPSS and Cronbach's Alpha to test its reliability. Data analysis uses the N-Gain Test for each indicator of critical thinking skills. The N-Gain test results show that applying the PBL learning model assisted by a virtual laboratory significantly increases the average critical thinking skills in the high category. Thus, there has been an increase in students' critical thinking skills through the learning process using the PBL learning model assisted by a virtual laboratory.

1. INTRODUCTION

The current era of globalization has brought significant changes in the world of education. The increasingly rapid flow of information and technological developments force us to produce individuals ready to face future challenges. Therefore, the skills needed in the 21st century are the main focus of education. 21st-century skills are better known as 4C, including critical thinking, collaboration, communication, and creativity. Through these skills, students are believed to be able to compete globally (Hardianti et al., 2020; Partono et al., 2021). One of the most important skills among 21st-century skills is critical thinking skills (Fitriani et al., 2020; Larsson, 2017). Critical thinking skills are not only considered

*Corresponding author
E-mail addresses: yulia.072621004@unpak.ac.id (Yulia Ramdinawati Syam)

an absolute necessity in facing the challenges of the times but also as a foundation for overcoming various complex problems and the ability to survive change (Reaves, 2019; Halim, 2022). Critical thinking skills are thinking skills that have the aim of proving something, interpreting something, and solving problems (Facione, 2015; Manurung et al., 2023). In an era of abundant information, students not only need to master information but also understand how to apply it wisely. Critical thinking skills are one of the most highly valued competencies. Critical thinking is also considered reasonable, and reflective thinking focuses on deciding what to believe or do (Ennis, 2011; Rudianti et al., 2021). The use of critical thinking in biology learning is carried out to face and solve life problems by the characteristics of natural science, which always prioritizes critical thinking to understand every learning that is very close to real objects (Mukti & Istiyono, 2018; Agnafia, 2019). Thus, critical thinking is an essential ability that can be used to indicate learning success in achieving competency standards. However, in reality, based on the results of the literature review that has been conducted, it was found that the condition of students' critical thinking skills is still in the low category (Ennis, 2011; Cahyani et al.,2021; Hayati & Setiawan, 2022). One of the factors causing low critical thinking skills in students is the less-than-optimal selection of learning methods and models by teachers (Liska Liska et al., 2021; Nuraida, 2019). Innovative learning methods and models can encourage students' 21st-century skills (Yulianti et al., 2022; Sari & Susiloningsih, 2015).

Knowing the importance of the learning methods and models teachers use, innovation is needed in learning methods and models to improve students' thinking skills. One learning model that can help develop critical thinking is problem-based learning or PBL. Problem-based learning has long been effective in training students' critical thinking skills (Maqbullah et al., 2018; Mareti & Hadiyanti, 2021). The PBL learning model confronts students with real problems relevant to the subject matter. Students are invited to investigate, analyze, and find solutions to the problem. This process encourages students to think critically, develop strong arguments, make wise decisions, and increase knowledge and understanding (Ali, 2019; Musaad & Suparman, 2023). PBL encourages problem-solving, first encountered in the learning process to develop students' skills in the relevant content knowledge. f(Arsika et al., 2019; Barret, 2017). Problem-based learning models have improved students' critical thinking skills (Putri et al., 2021; Setyorini Arum, 2021; Lestari et al., 2019). This model has also been proven to develop students' problem-solving abilities (Simanjuntak & Sudibjo, 2019; Aji & Hudha, 2017). Students' academic or learning achievement can be improved using problem-based learning models (Fitriani et al., 2020; Rahmat, 2018). Selain itu, penggunaan model pembelajaran ini juga dapat meningkatkan keterampilan proses sains (Usman et al., 2021; Hardiyanti et al., 2017; Nasir et al., 2023). As a form of intensifying problem-based learning, it is necessary to adopt a more modern approach, namely virtual laboratories. Virtual laboratories allow students to run experiments with interactive simulations through computer devices that can be done anywhere and anytime (Faour et al., 2018; Harjono et al., 2017; Paxinou et al., 2020; Stahre Wästberg et al., 2019). With the help of virtual laboratories, students can face situations closer to the real world, observe the results of experiments, and apply their understanding in practical contexts. Integrating PBL with virtual laboratories produces a powerful combination in training critical thinking skills. Students are faced with real problems and can try various solutions virtually. They can test their ideas, understand the impact of each decision, and develop their critical thinking through deeper exploration. This study aims to determine the increase in students' critical thinking skills after implementing the problem-based learning model with practical activities in a virtual laboratory.

2. METHOD

This study uses a pre-experimental method with a one-group pretest-posttest design. This means this study will conduct a pretest first, followed by a post-test after treatment. The subjects in this study were 30, involving eleventh-grade students of the MIPA program at Madrasah Aliyah in Bogor Regency. Participants were selected by purposive sampling with consideration of certain criteria. This study was conducted in stages including: a) conducting observations at Madrasah Bogor Regency, Indonesia; b) a pretest was given to investigate the level of students' critical thinking skills; c) implementing the learning process with PBL syntax and virtual laboratory activities; and d) a post-test was conducted to re-assess students' critical thinking skills after the learning process. Some of the data collected in this study were learning process data, students' critical thinking skills data, and student response data. The learning process data was collected using the observation method and documentation in the form of photos and videos of activities. This study also requires student response data taken using a questionnaire. In addition, this study also collects data related to students' critical thinking skills. The instrument used to collect data on students' critical thinking skills was an essay test. The essay test used to measure KBK was tested for validity twice, namely the validation test with expert judgment by expert lecturers and the empirical validation test on students, which was analyzed using Pearson Product moment and Alpha

Cronbach on SPSS. The critical thinking essay test refers to 5 indicators: providing simple explanations, determining the basis for decision-making, drawing conclusions, building basic skills, making further clarifications, and developing strategies and tactics (Ennis, 2011; Prihatin, 2022). The outline of the Critical Thinking Skills Instrument can be presented in Table 1.

Table 1. Critical Thinking Skills Instrument

	Critical Thinking Indicators	Sub Indicators	Question Number
1	Providing simple explanations (elementary clarification)	Asking and answering questions about an explanation and challenges	1, 2
2	Building basic skills (basic support)	Observing and considering the results of observations	3, 4
3	Concluding (inference)	Making inductions and considering the results of inductions	5, 6
4	Providing further explanations (advanced clarification)	Defining terms	7, 8
5	Developing strategies and tactics (Strategy and Tactic)	Deciding on a course of action	9, 10

Before being used, the instrument for measuring students' critical thinking skills will go through validity and normality tests. The validity test is carried out to determine whether the measuring instrument created is valid or effective for use. The validity test of the critical thinking skills instrument was carried out two times, namely by expert judgment by two expert lecturers and an empirical validation test on 30 twelfth-grade students. The results of the expert validation showed that out of 15 questions developed, most were valid, and two questions had revisions. Meanwhile, the results of the empirical validation were analyzed using the Pearson product-moment correlation assisted by the SPSS program. The question item is considered valid if the calculated r value exceeds the r table. The results of the validity test of the questions with the SPSS Pearson product-moment method showed ten valid questions and five invalid questions. A reliability test was carried out to determine whether the instrument was reliable. The reliability test in this study was carried out using the SPSS Alpha Cronbach method. The reliability test results of the critical thinking skills question instrument showed a reliability coefficient 0.627. It indicates high reliability, meaning that the instrument is suitable for use. The results of the validity and reliability test of this question instrument will be the basis for using the question items as a measurement tool for the achievement of students' critical thinking skills. After data collection is carried out, the data analysis of the critical thinking skills instrument is carried out by calculating the N-Gain value for each indicator.

3. RESULT AND DISCUSSION

Result

The valid and reliable question instruments were then used as pretest and post-test questions in the learning process using a problem-based learning model assisted by a virtual laboratory. In this case, fellow Biology teachers carried out observations. The results showed that all syntax in PBL had been carried out in stages. The learning process of the problem-based learning model assisted by a virtual laboratory can be presented in Figure 1. The results of improving students' critical thinking skills during the pretest before learning and the post-test were carried out after implementation. An analysis of the increase in the average score of critical thinking skills was carried out before using the virtual laboratory of the problem-based circulatory system. After using it, the N-Gain Test was carried out on each indicator of critical thinking skills. The results of the overall N-Gain average analysis by students obtained an average N-Gain value of critical thinking skills of 0.80. This value is included in the high category. The N-Gain value for each indicator of students' critical thinking skills can be presented in Table 2.

Table 2. Results of N-Gain Analysis for each indicator

No	Indicator Aspects	*Pretest*	*Postest*	*N-Gain*	Criteria
1	Providing simple explanations (elementary clarification)	37.50	90.83	0.85	High
2	Building basic skills (basic support)	35.83	91.67	0.87	High

No	Indicator Aspects	*Pretest*	*Postest*	*N-Gain*	Criteria
3	Concluding (inference)	15.00	86.67	0.84	High
4	Providing further explanations (advanced clarification)	19.58	81.67	0.77	High
5	Developing strategies and tactics (strategy and tactic)	12.92	72.92	0.69	Medium

Figure 1. PBL model learning assisted by virtual laboratory

Based on the student response questionnaire results, 92.9% of students felt that problem-based learning assisted by virtual laboratories was more interesting than regular learning. In addition, almost 82.1% of students felt motivated to implement learning with this model.

Discussion

Based on the analysis of the research results that have been conducted, it was found that students' critical thinking skills in the indicator of building basic skills or basic support have the highest N-Gain value, namely 0.87. Basic skills, namely observation, owned by students are part of basic science skills. Previous research revealed that basic science skills are part of observing and interpreting observation results (Kraus, 2023; Malik, 2015). Skills that are trained when students observe blood type test results and translate their observations through a virtual laboratory. This activity is carried out on both patients and four donors to decide the right blood type for transfusion, in addition to this skill being trained in circulation and blood pressure practicums. Because of the repetitive activities, this basic skill gets the highest score. Another indicator, namely strategy and tactics, has the lowest N-Gain value, 0.69. This indicator requires analytical skills, where they must connect questions, statements, and theoretical concepts to express opinions or information (Facione, 2015; Baderan, 2018). This indicator requires higher thinking speed to solve problems or make decisions and logic to solve problems (Sujanem & Suwindra, 2023; Febliza & Fauziah, 2020). This may be why the strategy and tactics indicators have the lowest N-Gain among the other indicators. These skills are trained in problem-based learning syntax, guiding investigations, and developing and presenting results, but this has yet to provide an increase in N-Gain, like other indicators that are quite high. Therefore, students need more trigger questions and assessments to develop these abilities. Previous research also revealed that trigger questions often given to students can improve students' critical thinking skills (Arum, 2021; Oktavianto, 2023).

Overall, the average N-Gain on the critical thinking skills indicator scored 0.80. It shows an increase in the high category. It means that applying the problem-based learning model with the help of a virtual laboratory can improve students' critical thinking skills. It aligns with previous research stating that problem-based learning can improve students' critical thinking skills (Agnesa & Rahmadana, 2022; Hasanah et al., 2021; Kristiyanto, 2020; Ngatiyem, 2021; Seibert, 2021; Selviani, 2019; Setyorini Arum, 2021). Critical thinking skills are one of the skills students must possess in the 21st century. Therefore, training critical thinking skills is an important thing that a teacher must do in the classroom to prepare their students to face the challenges of the 21st century. Selecting a problem-based learning model assisted by a virtual laboratory can help support students' critical thinking skills. It is in line with research that states that the environment can also support students' 4C skills, including critical thinking skills (Weng et al., 2022; Amalia et al., 2021). Implementing the virtual laboratory-assisted PBL learning model significantly increases students' average critical thinking skills. This study has implications for implementing the virtual laboratory-assisted PBL model, which can directly impact improving students' critical thinking skills so that this virtual laboratory-assisted PBL learning model can be used as a

reference for further research. The limitation of this study is that the scope of the study only focuses on one school, namely Madrasah Aliyah, using 30 eleventh-grade students of the MIPA program as a sample.

4. CONCLUSION

Based on the research results, it can be concluded that the problem-based learning model assisted by virtual laboratories has increased critical thinking skills. This is also supported by a survey conducted on students after the learning process. Therefore, the problem-based learning model assisted by virtual laboratories can be used as an alternative model in biology learning in the 21st century.

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