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Problem-based blended learning: The student's critical thinking skills in the respiratory system material

Na'imatul Jannah, Much Fuad Saifuddin

Biology Education, Faculty of Teacher Training and Education, Universitas Ahmad Dahlan, Indonesia

*Corresponding author: fuad.saifuddin@pbio.uad.ac.id

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ABSTRACT

Critical thinking skills should be integrated into high school biology education through problem-based blended learning.. This study aims to determine the effect of the Problem-Based blended learning model on students' critical thinking skills in the material on the respiratory system at SMA A. This quasi-experimental study used a nonrandomized control group, pretest–posttest design involving 2 XI classes, namely the control class, which consisted of 33 students and 32 students in the experimental class. Collecting data on critical thinking skills is using a test technique. The test instrument used is a question sheet (pretest and posttest). The data analysis consisted of analysis prerequisites in the form of a normality test and homogeneity test, as well as hypothesis testing in the form of the Mann-Whitney test. This study's results indicate a significant influence on students' critical thinking skills in the respiratory system material for class XI at SMA A after applying the Problem-Based blended learning model assisted by Google Classroom. This can be seen from the average test of critical thinking skills in the experimental class, which is higher than the control class.

INTRODUCTION

Current learning places more emphasis on student-centered learning (Ardian & Munadi, 2015). Student-centered learning supports students to learn actively, both through groups and individually, in building knowledge by utilizing information technology (Budiyanto, 2016). Implementing Student-Centered Learning is a learning approach that supports constructivist learning in the 21st century (Santyasa, 2018) to impart 21st-century skills to students (Mardhiyah et al., 2021). These skills are the 4Cs (critical thinking, communication, collaboration, and creativity) (Baderan & Indrajit, 2020).

Critical thinking skills are considered the main skills of the 21st century that students need to have (Dwyer et al., 2014; Schmaltz et al., 2017). These skills are important for students because they affect decision-making quickly and efficiently in dealing with problems in everyday life (Syafitri et al., 2021). The respiratory system material requires critical thinking skills because this material is abstract and complex. Critical thinking is essential in learning about the respiratory system as it enhances students' ability to analyze, evaluate, and synthesize information effectively. Research indicates that critical thinking skills are crucial for students to understand complex topics, such as the respiratory system (MacKay et al., 2016, Ridzal & Haswan, 2023).

The respiratory system presents challenges in teaching and learning due to various factors. Firstly, the abstract nature of the material itself makes it difficult for students to grasp concepts solely through traditional teaching methods (Yan et al., 2023). The complexity of the respiratory system, along with other challenging biology topics, leads to misconceptions and learning difficulties (ÇAKMAK & Bulunuz, 2022). Moreover, the limited time available for learning, whether online or face-to-face, adds to the challenge of comprehending the intricate details of the respiratory system (Meishanti et al., 2022).

Gadgets are synonymous with important things in the 21st century (Wahana, 2015; Wanidison & Shaddiq, 2021). Gadgets are devices that cannot be separated from the younger generation because they contain elements of information (Putri & Saifuddin, 2024). However, gadgets are still not optimally utilized by the younger generation. Currently, what is popular is social media such as Instagram, TikTok, and others that lack information to solve a problem (Arizal et al., 2021). Based on observations made at SMA A, it is known that there are still some problems in learning. The integration of gadgets in learning environments has not reached its full potential due to students' lack of guidance on their effective use (Yang et al., 2012). Hadijah (2020) highlighted that gadgets are often misused for non-educational purposes like playing online games, emphasizing the need for teachers to creatively structure learning activities to harness gadgets for educational purposes (Yang et al., 2012). Prastiyo (2023) pointed out that the current less structured learning process, particularly through Independent Learning Activity Units (UKBM), lacks problem-based questions, hindering the development of students' critical thinking skills (May, 2022). To address this, it is crucial to incorporate problem-based learning models to enhance students' critical thinking abilities and independence (Ramadhan, 2023). Additionally, the application of self-directed learning models has been shown to improve students' critical thinking skills, emphasizing the importance of fostering independence in learning (Wasyilah & Ilyas, 2021). Furthermore, the role of teachers in implementing differentiated learning activities, such as constructivism and inquiry, plays a vital role in promoting independent learning among students (Somadayo, 2023).

To overcome some of the existing problems in learning, there needs to be a solution to influence students' critical thinking skills, one of which is by applying the Problem-Based Learning model (Amin, 2017). The Problem-Based Learning model includes learning models with student-centered activities (Student Centered Learning) (Lopes et al., 2020). The characteristics of the Problem-Based Learning model are that learning focuses on solving real problems by students, and the teacher acts as a facilitator in learning (Dewi et al., 2019).

Using the Problem-Based Learning model in learning makes students more active so they can increase their understanding and build concepts from the knowledge gained by students and develop students' skills (Huriah, 2018). Building concepts from student knowledge obtained independently takes quite a long time, but students' time in exploring knowledge during learning is very limited. Therefore, learning with the Problem-Based Learning model must be well-prepared (Tyas, 2017). One of the solutions to overcome this condition is the implementation of blended learning.

Blended learning is learning that is carried out by combining face-to-face teaching with online learning. Through blended learning, students can gain knowledge quickly, and communication between teachers and students is unlimited (Irawan et al., 2017). Blended learning can improve students' 21st-

century skills such as critical thinking and information literacy. In addition, implementing this learning is more practical because it uses platforms such as the Learning Management System (LMS) (Utari et al., 2020). However, not all schools have an LMS, so it is necessary to have an application that supports the implementation of online learning. One application that can be used is google classroom (Asnawi, 2018; Rizal et al., 2020).

Implementing a Problem-Based Blended Learning model in teaching the respiratory system can foster collaborative learning among students, enabling them to tackle real-life problems effectively. This approach integrates face-to-face interactions with online platforms like Google Classroom, leveraging technological advancements to enhance learning experiences (Irwandi, 2024). By combining traditional and online learning, blended learning has been widely adopted in education, offering flexibility and improved learning outcomes (Vallée et al., 2020). The COVID-19 pandemic has further highlighted the importance of blended learning, emphasizing the need to overcome the limitations of conventional teaching methods through innovative approaches (Tong, 2023; Zhang, 2023). Research has shown that Problem-Based Blended Learning not only enhances students' problem-solving skills but also boosts their creativity and interest in learning, making it a suitable model for biology education (Irwandi, 2024). Moreover, the positive impact of blended learning on students' critical thinking skills has been demonstrated, indicating its effectiveness in promoting higher-order thinking (Lukitasari et al., 2019). Therefore, integrating Problem-Based Blended Learning into the study of the respiratory system can provide students with a comprehensive and engaging learning experience, preparing them to apply their knowledge to real-world scenarios effectively.

Using Google Classroom can help students learn; students can receive subject matter to be able to send assignments remotely. This application also helps teachers evaluate the assignments and can create smooth discussions between students and students and teachers (Marbun & Sinaga, 2021). In addition, Google Classroom is an application that is free, easy to use, and flexible for learning (Iftakhar, 2016). Based on these conditions, this research needs to be conducted to determine the effect of the Problem-Based Learning model based on blended learning (problem-based blended learning) on students' critical thinking skills in the material on the respiratory system in SMA A. This study presents the implementation of a problem-based blended learning (PBBL) model aimed at enhancing students' critical thinking skills in the context of studying the respiratory system. The PBBL approach synergistically combines face-to-face instruction with online platforms such as Google Classroom to facilitate collaborative learning, improve problem-solving abilities, stimulate creativity, and increase student engagement. Integrating traditional and digital learning methodologies, the PBBL model significant impact on students' critical thinking skills, effectively preparing them for real-world applications and fostering higher-order thinking in biology learning. This research underscores the efficacy of innovative pedagogical strategies in addressing the limitations of conventional teaching methods, particularly for complex subjects like the respiratory system.

METHODS

Research Design

This quasi-experimental study used a nonrandomized control group, pretest–posttest design with two research classes (Ary et al., 2010). The treatment class uses a Problem-Based blended learning model assisted by the Google Classroom application, while the control class uses Problem-Based Learning face-to-face in class. Each class is taught in three meetings. The research design that will be used is according to Ary et al. (2010) can be seen in Table 1.

Table 1
Nonrandomized Control Group Research Design, Pretest–Posttest Design.

Group	Pretest	Variable	Posttest
Experiment	Y1	X	Y2
Control	Y1	-	Y2

Table 1 shows the research grouping into two classes (experiment and control). Before the treatment, both classes were given a pretest (Y1), and after the treatment (X), a posttest (Y2).

Population and Samples

The study population was students of class XI MIPA SMA Negeri 1 Bantul consisting of 7 classes

with 251 students. The sampling technique used purposive sampling based on consideration of the average class value. The type of sampling used is simple random sampling randomly through a draw (Sugiyono, 2019). The sample of this study was 33 students of class XI MIPA 4 (control class) and 32 students of class XI MIPA 5 (experimental class).

Instrument

The data collection technique used is the test technique. The test technique is carried out by giving pretest and posttest questions to students. The data collection instrument used is the test instrument. The test instrument is a question sheet (pretest and posttest). The pretest and posttest questions used to measure students' critical thinking skills were a description (essay) totaling five questions. Each question was developed based on indicators of critical thinking skills, namely interpretation, analysis, evaluation, inference, and self-management of respiratory system material. The instrument has gone through an expert judgment validation process by five experts. Overall validation results show that the instrument is suitable for use.

Procedure

This research was carried out in several stages, starting with creating learning tools in the form of lesson plans, learning media, and learning instruments. Then, validation of the learning tools is carried out. After that, the research data collection process was carried out through learning activities. Learning was carried out on respiratory system material in two classes, namely class XI MIPA 4 as the control class and class XI MIPA 5 as the experimental class. This research was conducted through 3 learning meetings. In the control class, learning is carried out face-to-face in class using the Problem-Based Learning model. Meanwhile, learning in the experimental class was carried out using the Problem-Based blended Learning model, and asynchronous activities used Google Classroom and synchronous in class.

Asynchronous activities are carried out at least one day before synchronous classroom implementation. Student activities during asynchronous learning in Google Classroom are in the form of self-directed learning related to material through learning resources that the teacher has posted, questions and answers regarding material that has not been understood, as well as discussions with friends according to groups that have been determined in discussion forums regarding issues related to the respiratory system by the guidelines on the Student Worksheet (LKPD) that has been given. It collects data on students' critical thinking skills in the control and experimental classes through the pretest presented at the first meeting and the posttest at the last meeting synchronously in class. The final stage of this research is to summarize and analyze the research results using the Mann-Whitney test.

Data Analysis Techniques

The data analysis technique in this study used a hypothesis test in the form of the Mann-Whitney test using the Statistical Product and Service Solution (SPSS) software version 26.0, which was carried out after carrying out the normality test and homogeneity test. The results of students' critical thinking skills can be categorized into several categories based on Table 2.

Table 2

Critical Thinking Skills Category.

Interval (%)	Category
$80 < X \leq 100$	Very high
$60 < X \leq 80$	High
$40 < X \leq 60$	Moderate
$20 < X \leq 40$	Low
$0 < X \leq 20$	Very Low

Adapted from Karim & Normaya (2015)

RESULTS AND DISCUSSION

Data on the results of students' critical thinking skills in the form of the average pretest and posttest scores in the control and experimental classes can be seen in Figure 1.

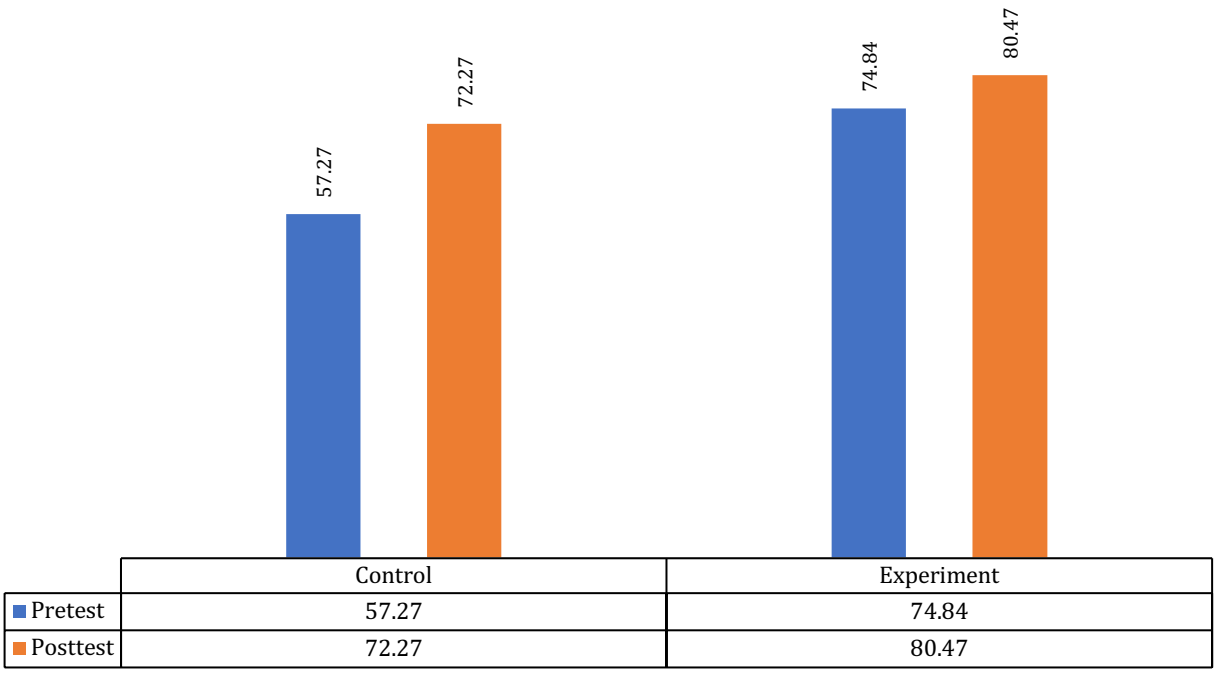


Figure 1. The Average Value of Pretest and Posttest Critical Thinking Skills

Figure 1 shows that the average results of students' critical thinking skills in the control and experimental classes were quite different for the pretest scores. Still, the post-test scores for the two classes were not much different. The mean value in the experimental class was higher than the control class, namely 74.84 in the pretest value and 80.47 in the post-test value.

Based on Table 2, the average critical thinking skills in the control class pretest are included in the moderate category. Meanwhile, the pretest in the experimental class is included in the high category. The post-test mean for critical thinking skills is included in the high category in the control class. Meanwhile, the post-test in the experimental class is included in the very high category. So, it can be seen that the mean post-test Critical thinking skills in both classes are higher than the pretest average. The data were then tested for normality with the Kolmogorov-Smirnov and homogeneity tests with the Levene test; the results are presented in Table 3.

Table 3
The Results of The Normality Test and The Homogeneity of Students' Critical Thinking Skills.

Test	Sig.	Decision
Normality (Kolmogorov-Smirnov)		
Control	0.200*	Normally distributed
Experiment	0.000	Not normally distributed
Homogeneity (Levene's test)	0.000	Not homogeneous

Table 3 shows that the data on critical thinking skills in the control class is normally distributed, while it is not in the experimental class. In addition, the homogeneity test results showed that the data was not homogeneous. Based on the results of the two prerequisite tests, the hypothesis was tested using the Mann-Whitney u-test. The results of the Mann-Whitney test analysis are presented in Table 4.

Table 4
Critical Thinking Skills Test Results with The Mann-Whitney U-Test.

	Critical Thinking Skills
Mann-Whitney U	349.000
Wilcoxon W	910.000
Z	-2.379
Asymp. Sig. (2-tailed)	.017

a. Grouping Variable: Class Treatment

Based on Table 4 shows that there is a significant difference in the value of critical thinking skills between the control class and the experimental class, so it can be stated that problem-based blended learning influences the critical thinking skills of class XI students of SMA Negeri 1 Bantul in the matter of the respiratory system.

Student activities in problem-based learning can help students develop conceptual and procedural knowledge (Lou et al., 2010), besides that students are required to be able to think actively to solve the problems presented so that the knowledge gained is more meaningful (Liu & Pasztor, 2022; Lutfiah et al., 2021), especially in the form of blended learning. The Problem-Based blended learning model provides a different experience for students. New learning activities make students active and not bored; the teacher facilitates students in developing their knowledge (Apriyani et al., 2017).

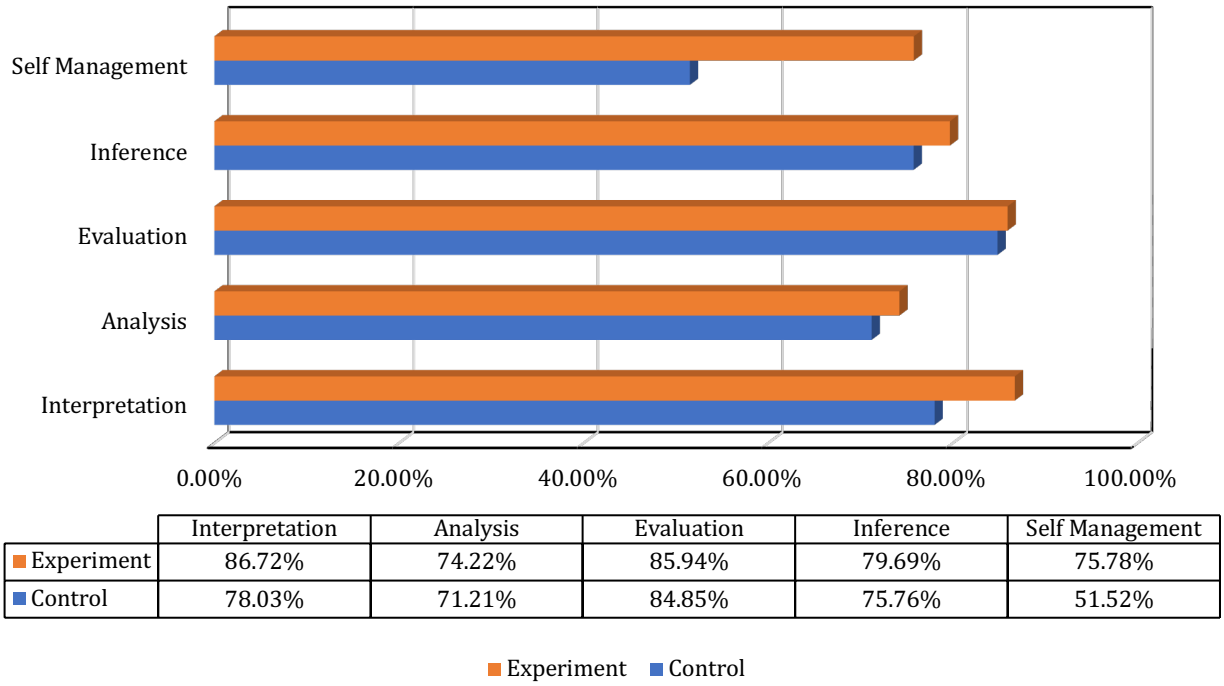
Problem-based blended learning provides an opportunity for students to discuss with their groups solving a problem given by the teacher; the discussion begins asynchronously via Google Classroom and continues face-to-face in class. So that students can be more mature in finding information independently regarding solutions to problems given so that students can develop their critical thinking skills. Ariyatun and Octavianelis (2020) revealed that students can develop critical thinking skills through discussion activities.

Critical thinking skills cannot be formed quickly during face-to-face learning in class. However, it must go through various learning activities that can develop ways of thinking (Shaw et al., 2019; Setyoko et al., 2019). Therefore, asynchronous learning activities outside of face-to-face learning hours can provide more time and hone ways of thinking and communicating. Implementing Problem-based blended learning integrated with Google Classroom contains activities asynchronously (studying learning resources, online discussions) and synchronously (discussions and presentations in class).

Asynchronous and synchronous blended learning is an advantage that makes students more involved in the learning process (Lapitan et al., 2021). Asynchronous activities through Google Classroom include four problem-based learning model syntaxes: student orientation to problems, organizing students to learn, guiding group investigations, and developing and presenting work. Meanwhile, the last syntax in the form of analysis and evaluation of the problem-solving process is synchronized in class. Asynchronous activities make students more prepared to participate in synchronous learning because students already have an idea regarding the learning that will be carried out in class. This can be seen from the average results of students' critical thinking skills in the experimental class is higher than in the control class.

The results of these critical thinking skills align with the research of Komariah et al. (2019), which states that applying the Problem-Based Learning model assisted by the google classroom application significantly affects students' motivation, interest, and high-level thinking skills. So, learning with the Problem-Based Learning model integrated with Google Classroom can be applied as optimal learning. Using Google Classroom for learning can make it easier for students to access material and collect assignments given by teachers (Dewi et al., 2021). In addition, students can also discuss with teachers and other students through the comments column or discussion forums created by the teacher (Asmawati et al., 2022). Assessment of students' critical thinking skills in this study was carried out with tests in the form of descriptions whose assessment was based on students' answers.

The student's critical thinking skills test is in the form of 5 essay questions with different indicators on each question. The indicators consist of interpretation, analysis, evaluation, inference, and self-management. The student's critical thinking skills test results were analyzed for each indicator. The following is the result of the calculation of the data obtained.



	Interpretation	Analysis	Evaluation	Inference	Self Management
Experiment	86.72%	74.22%	85.94%	79.69%	75.78%
Control	78.03%	71.21%	84.85%	75.76%	51.52%

Figure 2. Results Based on Indicators of Critical Thinking Skills

Figure 2 shows that the results for each indicator of critical thinking skills in the experimental class are higher than the control class. In addition, according to the category of critical thinking skills in Table 2, the indicators of critical thinking skills for the experimental class in the form of interpretation and evaluation are in the very high category. Meanwhile, indicators of analysis, inference, and self-management are in the high category. That is, the treatment of problem-based blended learning affects each indicator of critical thinking skills.

The indicator of critical thinking skills with the lowest percentage is the analysis indicator. Students are not yet optimal in answering questions related to solving a case by analyzing correctly. Meanwhile, the indicator with the highest percentage is the interpretation indicator. Students can understand and classify a case presented so that it has a precise meaning (Lismaya, 2019). One crucial thing that forms the basis of having critical thinking skills is that students must be able to interpret (Kitot et al., 2010).

Students' critical thinking skills can be developed by applying to learn centered on student interaction (Agboeze et al., 2013). Apart from that, it can also be through giving questions that require students to be able to solve a case and conclude based on the results of the investigation that has been carried out (Iakovos, 2011). Implementing problem-based blended learning can develop critical thinking skills because independent learning activities involve processing information, analyzing, and applying existing theoretical knowledge to solve a problem (Nazanrenko, 2015). To develop optimal students' critical thinking skills, learning activities must prioritize indicators of critical thinking (Agnafia, 2019) and consider using appropriate learning methods and models (Endang et al., 2021). The use of appropriate learning methods and models can affect the level of students' critical thinking skills. The results of this study indicate that implementing problem-based blended learning assisted by Google Classroom can develop students' critical thinking skills. So that with high critical thinking skills, students can be better prepared to deal with various problems that exist in their lives and are more appropriate in making decisions. However, this research is limited to only using five indicators of critical thinking skills so that for further research other indicators can be added. The obstacles to this research are limited research time and students are still not used to carrying out optimal activities on Google Classroom, so teachers need to familiarize students with using Google Classroom. The primary challenge in this research is the lack of adequate grouping functionalities in Google Classroom, coupled with students' insufficient time management skills. Despite these limitations, the researchers established small groups within Google Classroom and provided periodic reminders to assist students.

CONCLUSION

Problem-based blended learning positively affects students' critical thinking skills in learning the respiratory system for class XI at SMA A. Further research could focus on the comparative analysis of critical thinking skill development between traditional and problem-based blended learning methods to quantify the impact. Problem-based blended learning can provide better opportunities for students to explore various ways of solving problems. Investigations into specific problem-solving strategies and their effectiveness in a blended learning environment would provide deeper insights into best practices. Implementing this learning model must be widely used to encourage student mastery of 21st-century skills. Longitudinal studies examining the sustained impact of problem-based blended learning on 21st-century skills such as collaboration, communication, and creativity are recommended. The implementation of the learning model also needs to be varied with more varied learning media. Research on the integration of different multimedia tools and their effects on student engagement and learning outcomes could guide the optimization of blended learning environments.

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