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THE INFLUENCE OF PROBLEM-BASED-BLENDED LEARNING ASSISTED WITH COMPUTER SIMULATION ON STUDENTS' CRITICAL THINKING SKILLS

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Abstract
This study aims to determine the effect of Problem Based-Blended Learning (PBL) assisted by computer simulations on critical thinking skills and to determine student responses after learning. This type of research is quasi-experimental with a nonequivalent control group design. The research sample was taken using a saturated sampling technique, with VII D as the experimental class and VIIC as the control class. Data collection techniques in this study include multiple choice with reasons to measure critical thinking skills and student response questionnaires. The influence of PBBL assisted by computer simulations on critical thinking skills can be seen in the t-test and N-Gain test results. The t-test results obtained a value of $t_{count > table}$ or 5,616 > 1,998, indicating a significant difference in students' critical thinking skills. The results of the N-Gain test in the experimental class got a value of 0.668 and 0.468 in the control class, so both classes were in the medium category. The results of this study were supported by 83.05% positive responses from students in the outstanding category. The results of this study indicate that computer simulation-assisted PBBL affects students' critical thinking skills.

Keywords: PBBL learning, computer simulations, critical thinking skills

Abstrak
Penelitian ini bertujuan untuk mengetahui pengaruh Problem Based-Blended Learning (PBBL) berbantuan simulasi komputer terhadap kemampuan berpikir kritis dan mengetahui respon siswa setelah pembelajaran. Jenis penelitian ini adalah kuasi eksperimen dengan desain penelitian nonequivalent control group design. Sampel penelitian diambil dengan menggunakan teknik sampling jenuh, dengan kelas VII D sebagai kelas eksperimen dan kelas VIIC sebagai kelas kontrol. Teknik pengumpulan data pada penelitian ini meliputi pilihan ganda. Hasil uji-t diperoleh nilai $t_{hitung} > t_{tabel}$ atau 5,616 > 1,998 yang menunjukkan adanya perbedaan yang signifikan terhadap kemampuan berpikir kritis siswa. Hasil uji N-Gain pada kelas eksperimen memperoleh nilai 0,668 dan 0,468 pada kelas kontrol, sehingga kedua kelas berada pada kategori sedang. Hasil penelitian ini didukung oleh 83,05% respon positif dari siswa dengan kategori sangat baik. Hasil penelitian ini menunjukkan bahwa PBBL berbantuan simulasi komputer berpengaruh terhadap kemampuan berpikir kritis siswa.

Kata Kunci: pembelajaran PBBL, simulasi komputer, keterampilan berpikir kritis.

INTRODUCTION

Education in the 21st century plays a vital role in preparing a generation that has thinking skills and is skilled in operating technology and information media (Mayasari et al., 2016). Educators in learning must adapt to the role of 21st-century education. Minister of Education and Culture Regulation No. 21 of 2016 states that the Competency Standards for Graduates in the 2013 Curriculum learning are based on 21st-century competencies, which contain 21st-century skills to meet future needs. Referring to "The 4Cs" proposed by The Partnership for 21st Century Skills, critical thinking is one of the skills that students need to have in the 21st century. Ennis (2011) suggests that critical thinking is reflective thinking that emphasizes making decisions about what should be done. Students need to have critical thinking to solve problems related to the science concepts they encounter; the key to solving problems, facing challenges, living successfully, and being responsible in the present and future (Haryanti, 2017; Nugraha et al., 2017; Ramdani et al., 2020).

Observation results at SMP Negeri 29 Semarang show low critical thinking skills. That is supported by the use of daily test questions, which still need to be able to measure critical thinking skills because many still use levels C1, C2, and C3 but are still rarely used. Apart from that, when faced with a problem or question, students still find it difficult to answer it. That proves that one aspect of providing simple explanations on critical thinking skills still needs to be fulfilled.

Apart from that, during the COVID-19 pandemic, teachers and students must carry out previously done face-to-face learning in class and transform it into virtual face-to-face learning using platforms such as Zoom Meeting, thus making learning more teacher-centered. Technology is essential in supporting the learning process in this pandemic era. However, the use of technology during learning, such as media, still needs to be more varied because it only uses pictures and videos contained in PPT and does not use other technology-based media that can help students carry out experimental activities.

One way to train students' critical thinking skills and take advantage of technological advances is through learning, namely using a supportive learning model. Amin et al. (2020) combine Problem-Based Learning (PBL) with blended/hybrid learning, which can be known as the Problem Based-Blended Learning (PBBL) model, namely learning using PBL syntax, which is carried out using blended/hybrid learning. In PBBL, Amin et al. (2020) stated that the integration of PBL as one of the 21st-century learning models with blended/hybrid learning can facilitate students to formulate problems, think analytically, collaborate, utilize technology and information media to find out from various learning sources and create learning between teachers and students become more interactive.

Previous research relevant to the use of the PBBL model can train spatial thinking skills, learning outcomes, increase learning motivation, collaboration skills, cognitive knowledge, and critical thinking skills in students (Amin et al., 2020; Darwis et al., 2020; Dawilai et al., 2017; Ningrum et al., 2020; Sudjimat et al., 2019; Sujanem et al., 2018). In this research, due to the impact of the pandemic, the new combination of blended learning, according to Fuller (2021), is defined as learning with instruction carried out using computer media in asynchronous and synchronous form via video conferencing due to the absence of traditional face-to-face learning in the classroom. Thus, learning that integrates blended learning is one solution during the Covid-19 pandemic so that learning can continue to be implemented, as well as providing students with experiences in the form of varied learning in utilizing technological advances (Pujiasih, 2020; Yuliati & Saputra, 2020).

Technological advances in learning present blended/hybrid learning, and computer simulations can support the learning process, such as when conducting investigations/experiments, and stimulate students to be actively involved during learning (Kabigting, 2021). Computer simulation is a dynamic model generated by a computer in the form of media that aims to describe phenomena theoretically by original conditions that cannot be experienced directly and are of interest to curiosity and prepare students to learn (Kabigting, 2021; Sarabando et al., 2016). Computer simulation is expected to minimize the shortcomings of the PBL model mentioned by Setiyawan (2017), one of which is that it requires a long time to prepare media and tools for learning. Computer simulations that can be used for learning activities include JavaLab and PhET Simulation, which contain interactive simulations related to science material that require presenting objects directly.

Computer simulations such as interactive virtual media, and laboratories are effective in improving students' understanding of concepts, critical thinking skills, problem-solving abilities, and creative thinking (Novianti *et al.,* 2019; Sarabando *et al.,* 2016; Simanjuntak *et al.,* 2021). The use of PBBL can be applied to solar system materials because, according to Karyani *et al.* (2021) stated that material such as the impact of the Earth's rotation and revolution tends to be abstract and difficult to understand, which can result in low analytical skills in students, so it can be trained using the PBL model. Based on the description above, this research aims to analyze the effect of computer simulation-assisted PBBL on students' critical thinking skills and determine students' responses after learning is carried out.

METHOD

The study was implemented at SMP N 29 Semarang in the 2020/2021 academic year in the even semester. A saturated sampling technique was used in this research, with class

VII C as the control class and class VII D as the experimental class. This type of research is a quasi-experiment by design nonequivalent control group, as in Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O_3	-	O_4

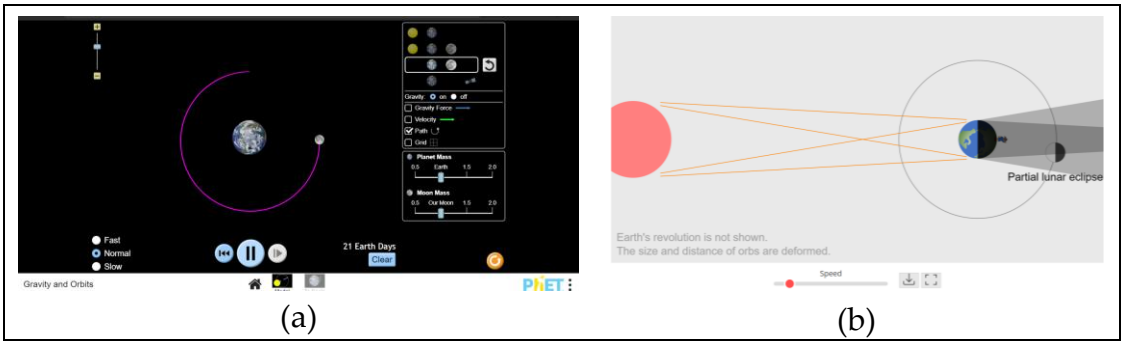
(Source: Sugiyono, 2017)

Information:

O_1 = experimental class pretest
O_2 = experimental class posttest
O_3 = control class pretest
O_4 = control class posttest
X = Treatment using the PBBL model aided by computer simulation
\- = Treatment using a conventional model

Treatment using PBBL was adapted from Amin *et al.* (2020), which was innovated with the help of computer simulations, including stages (1) orientation of students on problems, which aims to motivate students to be actively involved in determining problems face-to-face virtually (synchronously) through Zoom Meetings, (2) organizing students to learn collaboratively. Synchronously directed at Student Worksheets (LKPD) adapted to the PBBL stages assisted by computer simulation, (3) guiding investigations through JavaLab and PhET Simulation synchronously and asynchronously via Google Classroom, (4) developing and presenting work results asynchronously such as presenting LKPD screenshot results and representatives upload the announcement section for other students to respond to (5) analyze and evaluate the problem-solving process and provide material asynchronously.

An overview of the simulation used in PBBL learning given on solar system material for class VII/Even is presented in Figure 1.



(a) (b)

Figure 1. (a) Simulation of Earth and Moon Interaction, (b) Eclipse Simulation
(Source: (a) https://phet.colorado.edu/en/simulations/gravity-and-orbits
(b) https://javalab.org/en/category/astronomy_en/)

Data collection techniques in this research include test and non-test instruments. The test instrument used to measure critical thinking skills is reasoned multiple choice questions, which have been analyzed in the validity test, reliability test, level of difficulty, and different strengths so that 20 questions are used in the pretest and post-test. A non-test instrument in a response questionnaire determines students' responses after receiving the PBBL learning model aided by computer simulation. Data obtained from the critical thinking skills test results were analyzed using the normality, homogeneity, t-test, and N-Gain tests. Meanwhile, descriptive analysis is used to analyze student questionnaire responses.

RESULTS AND DISCUSSION

Critical thinking skills in the experimental and control classes were measured using reasoned multiple-choice questions at the beginning (pretest) and end of learning (post-test). In this study, the questions given during the post-test were the same as the pretest. Wulandari (2016) stated that the same pretest and post-test questions were used to determine whether there was an increase in student learning outcomes due to differences in Treatment in the two classes. Data on critical thinking skills from the experimental and control classes were analyzed using a homogeneity test, presented in Table 1.

Table 1. Homogeneity Test Results

Data	Class	Variance	F_{count}	F_{table}	Criteria
Pretest	Experiment	160,204	1,056	1,822	Homogeneous
	Control	169,176			
Post-test	Experiment	47,749	1,689	1,822	Homogeneous
	Control	80,634			

Table 1 shows that the pretest and post-test scores of students in the experimental and control classes meet the criteria for the $F_{calculated} < F_{table}$ at a significance level of 5% so that both classes are included in the homogeneous criteria. After the homogeneity test was carried out, the normality test was continued with the results presented in Table 2.

Table 2. *Pretest* and *Post-test* Normality Test Results

Data	Class	χ^2_{count}	χ^2_{table}	Criteria
Pretest	Experiment	9,505	11,070	Normally distributed
	Control	8,265		
Post-test	Experiment	8,628	11,070	Normally distributed
	Control	8,561		

Table 2 presents the normality test results from pretest and post-test data. Both classes have standard distribution criteria because they meet the criteria of $\chi^2_{count} < \chi^2_{table}$ with a significance of 5%. Based on the homogeneity and normality test results, the hypothesis test can be continued parametrically using the mean difference test (t-test), presented in Table 3.

Table 3. Results of the t-test for the experimental class and control class

Data	Class	t_{count}	t_{table}	Criteria
Post-test	Experiment Control	5,616	1,998	There are significant differences

Table 3 is the result of the t-test using *post-t-test* data from the experimental and control classes, which obtained $t_{calculated} > t_{table}$ or 5.616 > 1.998 with a significance level of 5%, indicating that there are significant differences in the two classes influenced by the learning model provided. This significant difference was influenced by the control class only being given a conventional model without any computer simulation. In contrast, the experimental class was treated using PBBL assisted by computer simulation.

Providing the PBBL model assisted by computer simulation in the experimental class influences critical thinking skills because it is trained through the learning stages. As with stages, focus on the problem and orient students to learn. Stages are carried out sequentially in blended learning sections synchronously via Zoom Meetings. That makes students jointly actively observe the video to motivate them on the problem. At this stage, assumptions will arise, and students will provide arguments and gain initial knowledge. After that, students are directed to the stage of investigating to prove their assumptions, looking for relevant learning resources via the Internet to obtain a more complete explanation. Therefore, the critical thinking skills of students in experimental classes can improve.

These results are by research by Hasna *et al.* (2021), Sujanem *et al.* (2018), and Triyanti (2022), that the integration of PBL with blended learning can help students master critical thinking skills. In line with research by Ningrum *et al.* (2020) and Sudjimat *et al.* (2019), PBBL can help students utilize online media and actively participate in every process to increase their thinking abilities.

The differences in students' critical thinking skills in the experimental and control classes are supported by the N-Gain test. The N-Gain test aims to determine whether there is an increase in critical thinking skills after learning. The indicators of critical thinking skills used in this research are, according to Ennis (2011), with the results of *N*-Gain calculations in the experimental and control classes presented in Table 4.

Table 4. Average Gain per Critical Thinking Skills Indicator

No.	Critical Thinking Skills Indicator	*N-Gain* Experiment	Criteria	*N-Gain* Control	Criteria
1	Focus on a question	0.662	Currently	0.502	Currently
2	Analyze the questions	0.732	Tall	0.608	Currently
3	Ask and answer questions	0.440	Currently	0.300	Currently
4	Consider the credibility of a source	0.721	Tall	0.500	Currently
5	Using existing knowledge, a	0.703	Tall	0.572	Currently

No.	Critical Thinking Skills Indicator	*N-Gain* Experiment	Criteria	*N-Gain* Control	Criteria
6	Summarize and consider conclusions	0.693	Currently	0.524	Currently
7	Make and consider inductive arguments and conclusions f	0.333	Currently	0.268	Low
8	Define terms and consider definitions	0.663	Currently	0.340	Currently
9	Identify various assumptions, i	0.752	Tall	0.474	Currently
10	Deciding on a course of action	0.711	Tall	0.432	Currently
	Average	0.668	Currently	0.468	Currently

Table 4 presents the results of the N-Gain test on each indicator and shows that the improvement in the experimental class is higher than in the control class. Obtaining N-Gain test results in both classes are in the range $0.3 \leq g \leq 0.7$. According to the gain index (g) category, according to Meltzer (2002), the average increase in the experimental and control classes is in the medium category. The difference in the average increase in *N-Gain* in the two classes was due to the experimental class using the PBBL model assisted by computer simulation, so the results were higher than those from the control class, which only used the conventional model.

The use of computer simulations in PBBL is at the investigation stage, carried out synchronously and asynchronously (Google Classroom). Through stages carried out asynchronously, students can access the material, study it first, reaccess it wherever and whenever, and access the investigation *link* on the LKPD before the learning meeting so that students are better prepared during learning, which affects their critical thinking skills. According to research by Anggraeni *et al.* (2019) and Habibah *et al.* (2022), learning that combines blended learning can improve students' critical thinking skills.

Computer simulations make it easier for students to carry out investigations. Students can still carry out investigations anywhere without needing to prepare equipment because they only need to access it via the website on a laptop or cellphone. In PBBL, assisted by computer simulation, the investigation stage provides students with the opportunity to practice their critical thinking skills because, with the investigation, students have direct experience in observing phenomena related to planets, the rotation and revolution of the Earth, and its impacts, lunar eclipses, and lunar phases. Figure 2 shows students carrying out the investigation stage using computer simulation.

Figure 2. Students carry out the investigation phase in PhET Simulation and JavaLab

Through the investigation stage, using computer simulations in the form of JavaLab and PhET Simulation, students obtain information data that can be used to help solve the problem. Variations in interactive computer simulations enable students to gain new knowledge and consider the results with the material and with other students so that their thinking skills will improve.

These results are supported by research by Herayanti & Habibi (2017), Kabigting (2021), and Simanjuntak *et al.* (2021), who stated that the use of computer simulations in learning allows students to gain the effect of new knowledge so that they can practice higher-level thinking skills. Apart from that, research by Arifin *et al.* (2022) stated that students can use simulations anywhere and anytime via computer or cell phone with or without an internet connection. In line with research by Amin *et al.* (2020) and Sujanem *et al.* (2018), technology-based PBL can improve high-level thinking skills; support at the stage of conducting investigations, students will make it easier to obtain data and information because observations are carried out to obtain direct results.

Apart from that, PBBL, with the help of computer simulations, facilitates practicing critical thinking skills through the stages of developing and presenting work results and analyzing and evaluating the problem-solving process. This stage was carried out in an asynchronous blended learning manner by presenting screenshots of the LKPD and representatives uploading the announcement section on Google Classroom to be responded to by other students. In this way, students will exchange ideas with other students through online discussions, gain broader knowledge. and conclude. So, PBBL learning assisted by computer simulations can develop students' critical thinking. In line with Yennita and Zukmadini (2021), in their research, PBL with blended learning can improve students' critical thinking skills. Figure 3 show an example of implementing this stage in Google Classroom.

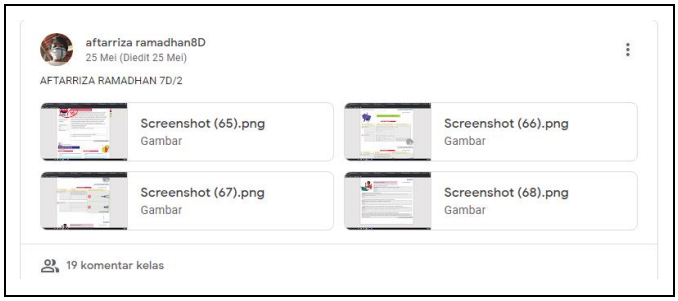


Figure 3. Students upload LKPD results for discussion in Google Classroom

Different from the experimental class, the control class is N-Gain. Students' critical thinking skills are lower because their learning uses the conventional lecture method via Zoom Meeting only and at the same time. The learning is more teacher-centered, and although videos have been facilitated to stimulate students to ask questions and answers, the implementation could be more optimal. The learning process does not contain stages that can help students practice critical thinking skills such as conducting investigations, analyzing, and evaluating. Apart from that, LKPD and material in the control class are only given during learning, so students depend more on the teacher and the material to be taught. Research by Wedekaningsih *et al.* (2019) shows that learning that is still teacher-centered has yet to maximize the development of critical thinking skills.

In the experimental class, responses were given to find out the students' reactions after using PBBL learning with the help of computer simulation. This questionnaire consists of 10 questions given to 32 students, obtaining a result of 53% with an outstanding response category and 47% with a good category. Learning using PBBL with the help of computer simulation is likely to be successful based on the questionnaire given because it gets an average result of 83.05% and is in an outstanding category. When the students are learning, they look active, interested, and enthusiastic about learning that uses computer simulations because it can make it easier for students to observe phenomena and celestial objects related to the matter of the solar system.

CONCLUSION

This research concludes that computer simulation-assisted PBBL significantly influences students' critical thinking skills and gets a positive response from students in the outstanding category. The results of this study were supported by 83.05% positive responses from students in the outstanding category. The results of this study indicate that computer simulation-assisted PBBL affects students' critical thinking skills.

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