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ANALYSIS OF THE EFFECTIVENESS OF PROJECT STEAM-BASED LEARNING MODEL TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS

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Abstrak
Tujuan penelitian ini adalah untuk mengetahui apakah kemampuan berpikir kritis siswa dipengaruhi oleh pendekatan pembelajaran PjBL berbasis STEAM. Ini adalah metodologi penelitian eksperimental semu. Kelompok kontrol nonekuivalen digunakan dalam desain penelitian penelitian ini. Dua ratus siswa merupakan populasi yang diselidiki. Teknik pengambilan sampel: digunakan sampling yang disengaja. Dua kelompok kelas yang berbeda memberikan sampel untuk penyelidikan ini. Terdapat dua kelas yaitu kelas B sebagai kelompok kontrol dan kelas A sebagai kelas eksperimen. Pra-penelitian, pra-pembelajaran, dan pasca-pembelajaran adalah tiga fase pengumpulan data untuk penelitian ini. Pemeriksaan dan survei digunakan pada tahap pra-penelitian. Pertanyaan penelitian dan hipotesis yang dapat diuji dikembangkan dengan mengolah dan menganalisis data setelah dikumpulkan. Penelitian ini menggunakan perangkat lunak IBM SPSS Statistics untuk melakukan uji-t dan uji statistik parametrik lainnya. Hasil uji hipotesis data dan post test pada kelas eksperimen dan kelas kontrol dengan menggunakan uji t memberikan bukti bahwa penerapan model pembelajaran PjBL berbasis STEAM memberikan dampak terhadap kemampuan berpikir kritis siswa, sejalan dengan temuan penelitian dan percakapan. Baik kelas eksperimen maupun kelas kontrol saling mengungguli dalam hal nilai rata-rata pascates. Di atas 70 adalah skor rata-rata untuk kelas eksperimen, dan di atas 60 untuk kelompok kontrol.
Kata kunci: Model Pembelajaran PJBL Berbasis STEAM, Keterampilan Berpikir Kritis

Abstract
The purpose of this research is to find out if students' critical thinking abilities are impacted by the STEAM-based PjBL learning approach. It is a quasi-experimental research methodology. An nonequivalent control group was employed in this study's research design. Two hundred pupils made up the population under investigation. Sampling technique: intentional sampling is used. Two different class groups provided samples for this investigation. There are two classes: class B is the control group and class A is the experimental class. Pre-research, pre-learning, and post-learning were the three phases in which the data for this study were collected. Examinations and surveys were employed in the pre-research stage. Research questions and testable hypotheses are developed by processing and analyzing the data after it has been gathered. This study made use of IBM SPSS Statistics software to perform the t-test and other parametric statistical tests. Test results and post-test data hypothesis in the experimental class and control class using the t-test offer evidence that the application of the STEAM-based PjBL learning model has an impact on students' critical thinking skills, in line with research findings and conversations. Both the experimental class and the control class outperformed each other in terms of average post-test scores. Over 70 was the average score for the experimental class, and over 60 for the control group.
Keywords: STEAM Based PJBL Learning Model, Critical Thinking Skills

INTRODUCTION

Through education, society can be empowered to solve increasingly complex global problems. In the 21st century, many changes have occurred so they can adapt through education to develop their potential, such as personality, intelligence, behavior, and excellence (Anisa et al., 2021). Individuals in

this century need to learn the skills needed to enter the world of work, one of which is critical thinking (Mamusung et al., 2021). Modern technology is necessary for each individual to be able to put their theoretical knowledge into practice. This is anticipated to improve their character and productivity (Wahdiniawati et al., 2023). In the field of education in the 21st century, there are skills that have been developed (Ekasari et al., 2021). Some of these initiatives involve updating the national curriculum to the curriculum, which is centered on 21st century learning (Manullang & Satria, 2020). However, in Indonesia, there is still a dearth of teaching that specifically encourages students to develop high-level thinking skills, so the quality of education is still quite low (Manullang, 2021). Therefore, it is very important to focus on skills training, one of which is critical thinking (Wahdiniawati et al., 2014).

In terms of science, Indonesia is ranked 71st out of 79 countries based on the results of several prior surveys. Placed 75th out of 132 countries is Indonesia. In addition, it reveals that Indonesia ranks 44th in the world among 47 nations in the scientific domain (Wahdiniawati & Sarinastiti, 2023). There is compelling evidence from a number of survey results that Indonesian students still struggle with critical thinking (Kurniawan & Wahdiniawati, 2023). The teaching and learning process is teacher-centered and repetitive since schools continue to use traditional teaching methods for lessons, as per the observations of researchers. Additionally, students struggle to comprehend the subject matter, and they typically lack critical thinking abilities. Situations like these suggest that instructional activities don't adhere to the principles of student-centered learning (Puspitoningrum, 2015). When taught by a lecturer, students find it challenging to come up with their own learning concepts or ideas. One of the 21st century competencies, critical thinking, is hard for students to acquire (Pitoyo et al., 2019). Critical thinking broadly means making decisions based on knowledge and communication that have been collected while using adequate thinking and reasoning. Critical thinking skills include the capacity to analyze information, express a point of view supported by facts, maintain an open mind, and conduct research on newly discovered knowledge. Therefore, growth in efficient information retention, even the cultivation of cognitive talent, depends on critical thinking (Puspitoningrum et al., 2023).

Using instruction that can impact students' critical thinking abilities for the twenty-first century is one way to try to address the issues mentioned above. To do this, in particular, the STEAM (Science, Technology, Engineering, Art, and Mathematics)-based PjBL (Project-Based Learning) learning model can be applied. PjBL learning is a cognitive exercise that enhances higher order thinking abilities (Mamusung et al., 2019). Through the use of authentic thinking to solve problems, the PjBL learning model helps students develop better study habits. In a project-based learning environment, the instructor takes on the role of a facilitator, collaborating with the students to develop pertinent assignments and questions that assess their learning and promote the acquisition of social and intellectual competencies (Setyawati et al., 2023). For students working on a project to be able to work independently and create a realistic product and presentation, they must participate in problem solving, decision making, or investigative activities. Therefore, because it is contextual and can aid in the development of students' critical thinking abilities, project-based learning (PjBL) is among the best strategies for accomplishing 21st century educational goals (Solehati et al., 2022).

The STEAM approach, which integrates art into learning, is a multidisciplinary approach that developed from the STEM approach. Elements of art (art) are a great way for students and teachers to express themselves, communicate, use their imagination to be creative, pay attention to what they see, and think to hone their cognitive abilities, including listening, problem solving, and decision-making. Learning with a STEAM approach involves students actively, involves practical activities, and is directed at real-life situations (Amelia & Setyawati, 2023). Additionally, STEAM education can help students increase their capacity for teamwork, problem solving, and critical thinking. Studies have demonstrated that the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) into Project-Based Learning (PjBL) has a positive impact on both critical and creative thinking. This suggests that the STEAM-based PjBL learning approach improves critical thinking skills (Safrida et al., 2023). Conducting additional research on the impact of the STEAM-based PjBL learning model on critical thinking in the classroom is essential and intriguing. Consequently, it will be feasible to acquire data regarding the enhancement of students' critical thinking abilities in relation to learning through the implementation of the STEAM-based PjBL learning model (Simamora & Elviani, 2022).

Critical thinking is one of the abilities required in the twenty-first century. One of the objectives of national education is to help students grow into human beings capable of critical thought (Safrida, 2017). Nonetheless, several studies reveal that pupils' critical thinking abilities are still deficient. Students' learning process has an effect on their ability to think critically. Therefore, efforts must be made to enhance their critical thinking abilities so that they can learn and develop in a positive way (Safrida et al., 2023). The curriculum must be designed with the needs of the student in mind. Because student-centered learning allows students to think freely, express their opinions, and study topics that interest them, it can enhance their critical thinking skills (Darmadi & Rifai, 2022). To help students overcome their learning challenges in comprehending abstract material and developing critical thinking abilities, the appropriate learning model needs to be selected and implemented (Fajri et al., 2020). The learning model needs to be carefully chosen in order to achieve the intended outcomes and guarantee a seamless learning process (Herzon et al., 2017). One type of learning model that can be used to support student-centered learning is STEAM-based Project-Based Learning (PjBL) (Wayudi et al., 2020). By creating their own knowledge while studying with STEAM-based PjBL, students can improve their critical thinking skills. Multiple studies' findings support the idea that STEAM-based PjBL helps students develop their critical thinking abilities.

METHOD

The most effective technique for examining cause and effect is experimental research, which is what is being done here. Quasi-experimental research methodology is employed. An experimental group and a control group that are not selected at random are used in the quasi-experimental method. There was a pretest and a posttest for both groups. The experimental group was the only one to receive care. This study's research design employed a nonequivalent control group. A population is a collection of people who share a trait that sets them apart from other groups. There were 200 students in the study's population. Purposive sampling, a technique for selecting samples based on specific considerations or research objectives based on the attributes or characteristics of a population, is used in the sampling procedure. In this study, the researchers took into account a homogeneous sample when determining the sample. Two class groups with nearly identical features and average skill levels served as the research samples. Class B serves as the control group and employs the guided inquiry learning model with a scientific slant. The experimental class, designated as A, employs the PjBL learning model, which is based on STEAM. In this study, there were three stages to the data collection process: pre-research, pre-learning, and post-learning. During the pre-research phase, tests and questionnaires were used. Following collection, the data is processed and examined to enable the development of research questions and testable hypotheses. Prior to that, the normalcy and homogeneity tests two statistical prerequisites are run on the data. Parametric statistical tests are used for hypothesis testing if, following the completion of prerequisite tests such as homogeneity and normality tests, the data population results are homogeneous and normally distributed. The t-test is used in this study's parametric statistical tests with the aid of IBM SPSS Statistics 25.

RESULTS AND DISCUSSION

The findings of the initial ability test (pretest) and the last ability test (posttest) are utilized to assess students' critical thinking abilities. Both the initial and final ability tests use the same test instrument to assess critical thinking skills. The experts have evaluated and tested the critical thinking ability test used in this study to determine its suitability in terms of validity, reliability, distinguishing power, and degree of difficulty. The remarkable test results indicate the instrument's appropriateness for utilization. These questions are the ones used in the pretest. The average pretest results for both the experimental and control classes provide evidence that students' critical thinking abilities are relatively low. This is corroborated by the pretest averages, which are in close proximity to the maximum score of 100 and stand at 39% and 37% for the control and experimental classes, respectively. The critical thinking abilities of students are lacking in five specific areas: elementary clarification, basic support, inference, advance clarification, and strategy and tactics. The average initial proficiency level of students in the elementary clarification aspect was 33% in the experimental group and 35% in the control group. The students are still struggling to generate questions and answers in this field. The experimental class exhibited an average initial ability of 34% in the basic support area, while the

control class demonstrated an average initial ability of 35%. The reason behind the low critical thinking abilities of students is that they are unable to give reasons for developing fundamental skills.

In the experimental class, students' critical thinking ability in the inference component was 34%, while it was 36% in the control class. The reason for the low inference ability of the students was that they were still unable to draw conclusions. In the experimental class, students' critical thinking ability was 35%, while in the control class it was 38.38% in the advance clarification area. Because they haven't been able to offer more explanations, students' critical thinking abilities in the advance clarification area have been lacking. The experimental group demonstrated a 38% proficiency in critical thinking skills related to strategy and tactics, while the control group showed a 40% proficiency. Students' incapacity to decide how to approach problems involving organizing strategies and tactics to determine the validity of an opinion regarding real-world occurrences is the root cause of their low critical thinking skills in the strategy and tactics domain. Based on the results of direct observation, the teacher employs the lecture method to make sure that students only pay attention. Students find it more difficult to understand and retain the material as a result, which makes it harder for them to resolve conceptual conflicts in the context of higher-order thinking. Previous studies have supported this, showing that because of the classroom learning model's failure to prepare students for problems involving analysis, evaluation, and creation, students' critical thinking skills remain low.

Ultimately, the control and experimental groups of students experienced a substantial increase in their critical thinking capabilities. The experimental class, which received instruction based on the PjBL learning model incorporating STEAM (Science, Technology, Engineering, Art, and Mathematics), achieved a significantly higher average score on the posttest compared to the control class, which was taught using the guided inquiry learning model with a scientific approach. The experimental class achieved an average posttest score of 74%, while the control group obtained a score of 62%. The reason for this is that the experimental class utilizes the STEAM-based PjBL learning model (Science, Technology, Engineering, Art, and Mathematics), enabling students to actively engage in group discussions and exploration. This approach enhances the process of learning and fosters the development of students' critical thinking skills by simplifying their comprehension of the subject matter. The STEAM components in this research are: science (S) for using concepts; technology (T) for searching for information; use of tools in making projects; and presenting project results in e-posters; engineering (E) for designing, as well as using techniques to design products; art (A) to build communication during discussions and presentations; and finally, mathematics (M) for calculations in determining differences. In this way, students become trained in exploring contextual problems using the knowledge they already have, due to the involvement of STEAM in the learning process.

There are five stages in the STEAM-based PjBL learning model: application, research, reflection, discovery, and communication. Discussions about the subject matter are held during the reflection phase to help students comprehend it and share solutions to problems. During the learning process, students work in groups of friends to solve problems on LKPD. During the research phase, students gather pertinent information from online resources or textbooks. During the discovery phase, students work in groups of friends to create simple experiments and design projects. During the application phase, students create basic experiments and end products from completed projects. The students presented their work during the communication phase in order to enhance teamwork and communication skills within the classroom setting. The experimental class demonstrated a 70% proficiency in critical thinking abilities during the elementary clarification task, while the control class exhibited a 60% proficiency. The rise in students' capacity to formulate questions and provide responses tailored to specific reasons can be ascribed to their developing aptitude. The implementation of the STEAM-based PjBL learning model led to a significantly greater increase in academic performance within the experimental class, particularly observed during the research stage. Students must voice their opinions and ask questions during the research stage in order to improve their ability to do so. This is also consistent with other research, which indicates that during the research phase, teachers can impart knowledge to students and give them the chance to express their opinions and queries; the teacher's role is limited to serving as a facilitator to increase student participation in class activities.

In the experimental class, students' critical thinking ability in the basic support area was 77%, compared to 65% in the control class. The reason for this notable increase was that students were able

to give justifications for developing foundational explanation skills. The group that was exposed to the STEAM-based PjBL learning model demonstrated a more significant improvement, specifically during the communication phase. Students have the chance to present the outcomes of completed projects during the communication stage. This is also consistent with other research, which indicates that you can transform the learning process into an activity that presents engaging learning opportunities for students by utilizing the communication stage. In the experimental class, students' final critical thinking score was 77%, while in the control class, it was 74% in the inference area. The notable increase can be attributed to the students' ability to derive conclusions from real-world scenarios. The experimental class experienced a significantly greater increase, particularly during the application stage, due to the implementation of the STEAM-based PjBL learning model. During the application process, students complete their projects. The aim of the project is to solve problems so that students can understand their role in everyday life. The ability to think critically involves thinking with a purpose, such as pointing out something, deciphering what something means, or solving a problem. The point is that in this project, students are trying to prove whether to provide an answer or solve a problem. Students will draw conclusions from their experiments before making decisions.

In the experimental class, students' final critical thinking score in the advance clarification section was 71%, while it was 56% in the control group. The reason for this notable rise is that students can now define terms and think about definitions when giving implicit explanations and reasoning. The application of the STEAM-based PjBL learning model resulted in a significant increase in the experimental class, particularly during the discovery stage. Students are already familiar with the procedures needed to complete the project in the LKPD at this point. Students also set up the equipment and supplies required to complete the project as part of this understanding. To help students' critical thinking abilities, they also get to vote on the project designs that are available at this point. Previous research supports this, stating that when solving a problem, critical thinking places a high value on the capacity to formulate, define, argue, and draw conclusions. In the control group, students' final critical thinking score in the strategy and tactics area was 54%, while in the experimental group, it was 69%. Students were able to choose how to solve problems involving organizing strategies and tactics to ascertain the veracity of an opinion in everyday life, which led to this notable increase. The experimental group exhibited a more substantial growth in learning outcomes following the implementation of the STEAM-based Project-based Learning (PjBL) instructional approach, with the reflection stage being particularly influential. Currently, students are being prompted to analyze real-life events in order to identify contextual issues and make informed decisions regarding potential courses of action. During the phase of reflection, students have the opportunity to combine experiential learning with their academic knowledge. Based on the findings of the posttest statistical hypothesis test, the null hypothesis (H0) is rejected, while the alternative hypothesis (H1) is accepted. Based on the results of the statistical hypothesis test, it can be inferred that there exists a disparity in the final average critical thinking skills between students in the experimental class and those in the control class. The observed disparity in the ultimate scores can be attributed to the distinct methodologies employed in the instruction of the two classes. The experimental group employs the Science, Technology, Engineering, Arts, and Mathematics (STEAM) integrated Project-based Learning (PjBL) model, whereas the control group utilizes the guided inquiry learning model with a scientific orientation. The findings of this study align with prior research, indicating that the STEAM-oriented Project-Based Learning (PjBL) instructional approach has a significant impact on students' development of critical thinking skills.

CONCLUSION

The utilization of the STEAM-based PjBL learning model has been observed to impact students' critical thinking skills, as indicated by the outcomes of posttest data hypothesis testing conducted on both the experimental and control classes, employing the t-test. This conclusion is drawn from a combination of research findings and discussions. The experimental group outperformed the control group in terms of average posttest scores. The experimental group exhibited a mean score of 74, whereas the control group demonstrated an average score of 64. Based on the findings of the research, the subsequent recommendations can be put forth. Considering the implementation time required for the STEAM-based Project-based Learning (PjBL) model, it is recommended that educators possess the ability to optimize the utilization of instructional time in the classroom. In the context of the

STEAM-based PjBL learning model, it is imperative for educators to demonstrate a considerable level of creativity in order to effectively foster active student engagement during the reflection phase. This is particularly crucial as the majority of students tend to exhibit passivity during this stage. Educators seeking to incorporate the STEAM-based PjBL (Project-Based Learning) pedagogical approach are encouraged to seek out additional projects that possess a strong connection to real-world contexts and experiences.

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