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Enhance Critical Thinking Skills in Application of PjBL-STEM on Fluids Dynamics: A Literature Study

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Abstract: The purpose of this study is to comprehend and describe the application of project-based learning integrated STEM (science, technology, engineering, and mathematics), or PjBL-STEM, to the study of fluid dynamics in order to improve critical thinking skills. Utilizing qualitative data collection methods, such as literature studies, is the research methodology used in this project. Theoretical sources that are relevant to the issues identified are searched for to collect data for this study. The data obtained is subsequently examined using descriptive analysis techniques. According to the data analysis, the N-gain score revealed an improvement in students' critical thinking skills. These conclusions are also supported by other pertinent investigations. According to a review of the research, using PjBL-STEM to study fluid dynamics may enhance critical thinking skills.

Keywords: Critical thinking; Fluid dynamics; Project-based learning; STEM.

Introduction

Education is a crucial component of a country's progress and sustainability, especially in preparing the next generation to compete in the twenty-first century (Mardhiyah et al., 2021; Sole and Anggraeni, 2018). Students must possess skills that are contemporary, as science and technology are advancing at an accelerating rate (Waluyo and Wahyuni, 2021). Critical thinking, creativity, communication, and teamwork are among the 21st century skills known as 4C (Idawati, Muhardjito, and Yuliati 2019; Maskur et al., 2020; Valtonen et al., 2021). The concept of learning to train these 21st-century skills has been adapted in the 2013 Curriculum or commonly known as K13 through a scientific approach and authentic assessment.

The idea of a scientific approach that incorporates a variety of learning models is one concept that has been adopted into the curriculum. The learning models that are advised by the 2013 Curriculum are guided inquiry, discovery learning, problem-based learning, and project-based learning (Issa and Khataibeh, 2021; Solihin et al., 2021). The adoption of these learning models is anticipated to improve students' abilities, particularly their critical and creative thinking abilities (Anazifa and Djukri 2017; Huang et al., 2017).

One of the implementations of the K13 applied in high school level education is a natural science especially in physics. Critical thinking skills must be taught to students because they are one of the key components in the study of physics (Himawan and Ariswan, 2023). When deciding whether to do or believe, critical thinking is the feasibility of thoughtful thinking (Nygren et al., 2019). When studying, critical thinking is used to comprehend, analyze, and defend one's own arguments as well as the arguments and opinions of others.

The critical thinking skills possessed by students in Indonesia are still low and it can be seen from some findings in previous studies (Sumarni and Kadarwati, 2020). Based on these facts, there must be synergy between the strategy and the learning model to achieve the goal. Innovation is needed in the process of learning physics that must be done, one of which is applying project-based learning.

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Project-Based Learning (PjBL) is an instructional approach that emphasizes learner autonomy, student-centered teaching, collaborative learning, and task-based learning while teaching curricular topics through a project (Samsudin et al., 2020). Project-based learning has the following syntax: 1) introduction and team planning of the project; 2) the preliminary phase of information collecting study; 3) the development, fabrication, and preliminary assessment of presentation and prototype artifacts; 4) completion of the second research phase; 5) creation of the final presentation; and 6) publication of the work or items (Bender 2012; Parno et al., 2022).

The integration of STEM subjects—Science, Technology, Engineering, and Mathematics—into classroom instruction is one strategy to keep education current in the age of globalization (Baran et al. 2021). The creation and finishing of a product as the solution to a context-specific challenge reflects the integration of STEM elements in learning. (Ergül and Kargın 2014; Pramasdyahsari et al., 2023). The PjBL-STEM model is one of collaborative learning because of its characteristics, which emphasize students learning actively and in groups and sharing information with each other so that it helps open the horizons of other students' thinking (Haryadi and Pujiastuti 2022; Mamahit et al., 2020). The PjBL learning model is encouraged when using the 2013 curriculum since it can offer practical experience while studying, whereas STEM is a learning strategy. The design process and a systematic approach to issue solving both key PjBL and STEM characteristics (Sunyoung et al., 2016; Putri and Dwikoranto 2022).

In physics learning, there is a fluid dynamics topic closely related to aspects of STEM because in this material all aspects of STEM are involved (Putri and Dwikoranto 2022). Judging from its basic competencies, this fluid dynamics is suitable for the PjBL model, because in basic competence there is a create and test simple project.

Based on the description, the effectiveness of physics science learning can be an alternative to enhancing students' critical thinking skills. Therefore, this article will be discussed the Enhance Science Literacy Skills in Application of PjBL on Fluids Dynamics. With the study of the literature on research results on PjBL-STEM, It is anticipated that it will serve as a resource for teachers implementing learning innovations.

Method

This research is a literature study that combines secondary data from research findings that have been published in both national and international journals and proceedings. According to Zed (2014), An activity connected to the process of gathering library data is a literary study. In line with Nazir (2014), Literature studies are a method of gathering information by looking at books and other works of literature that deal with issues and offer solutions. The data used in this research literature study can be seen in Table 1.

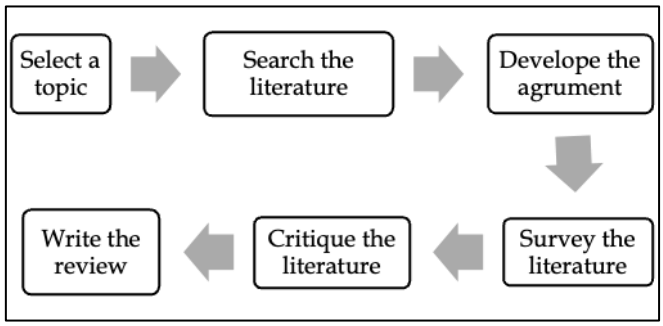

Figure 1. The Literature Review Process

Tabel 1. Research Data from Relevant Journals

Researcher	Conclusions
Indriyana and Susilowati (2020)	The STEM project-based learning approach had an impact on the students' critical thinking and teamwork abilities. It was in the medium category.
Lestari, Sarwi, and Sumarti (2018)	The project-based learning learning model STEM education can help students develop their scientific method and creative thinking skills.
Widyasmah, and Herlina (2020)	There are differences between the increase in students' creative thinking abilities before and after the application of the STEM learning approach, and the implementation of the STEM learning strategy has raised the creative thinking skills at a significant level of 0.000.

This study's purpose is to determine and describe how PjBL-STEM is applied to Fluid Dynamics topic to enhance students' critical thinking skills. By seeking for theoretical sources that are related to the issues identified, data for this study was gathered. Afterward, descriptive analysis techniques are used to examine the data. Descriptive analysis methods are done by describing a problem or facts obtained by explanation and decomposition and then analyzed by researchers. Furthermore, the literature review process of this research is described in the following scheme.

Result and Discussion

This analysis is used to determine the improvement of critical thinking skills through PjBL- STEM learning. Based on an analysis of the results of research conducted

by Indriyana et al. (2020), The puposel of this study was to examine the effect of a STEM model project-based learning strategy on junior high school students' critical thinking and cooperation skills while they learned natural science. The study uses two groups: the experimental group that applied project-based learning model with STEM-oriented, and the control group applied a scientific approach. The data obtained is N-gain data from the two class groups. Data on the N-gain of the class groups can be seen in the Table 2.

Table 2. N-gain Data

Group	N-gain	Category
Experimental	0.41	Medium
Control	0.28	Low

Based on Table 2. The The experimental group got an N-gain score of 0.41 in a medium category and the control group got an N- gain score of 0.28 in a low category. The results of increasing students' critical thinking skills in experimental group and the control group can be seen in the following figure.

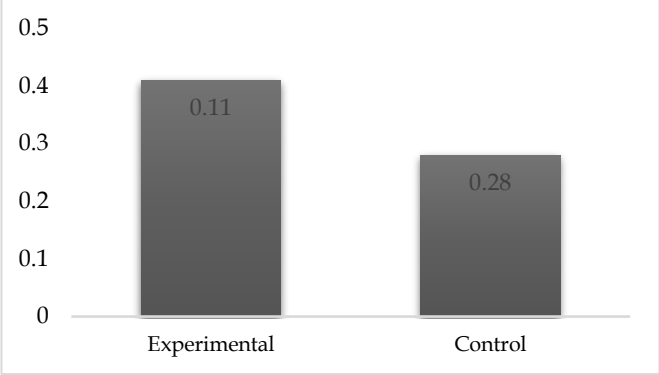

Figure 2. The Value of N-gain in All Groups

The figure above shows that the N-gain score of the experimental group is one level higher than the control group. Based on the findings of this research, it can be stated that after receiving treatment, each group's progress in critical thinking skills varied. From the above research, it can be concluded that PjBL-STEM can enhance the critical thinking skills that students have. The results of this study are in line with what was revealed by Parno et al. (2020) which state that the treatment given to students while they are learning can affect the results obtained by students. This is also supported by research conducted by Anazifa and Djukri (2017) which also state that the treatment given during learning can improved students' thinking skills.

Another study conducted by Lestari et al. (2018) aims to know the effect of STEM based learning based learning model on science process and creative thinking skill. In this research, two groups—the experimental group 1 and the experimental group 2—were used. Project-based learning with a STEM focus was used to treat experimental group 1; project-based learning alone was used to treat experimental group 2. The data obtained from this study were N-gain and data on the significance of the difference in average improvement in students' critical thinking skills from pretest and posttest results in experimental group 1 and 2. Data on pretest, posttest, and n-gain can be seen in Table 3.

Table 3. Pretest, Posttest, and N-gain Data

	Experimental Class 1			Experimental Class 2		
	Pretest	*Posttest*	N-gain	*Pretest*	*Posttest*	N-gain
Average	57.90	85.96	0.67	51.96	78.1	0.54

In Table 3. There are data regarding the results of the pretest and posttest in the experimental class 1 that applies the PjBL-STEM model and the experimental class 2 that applies the PjBL model only. The data includes the average score and N-gain. Based on these data, there was an increase in the scores obtained by students after being given treatment. The results of increasing scores on pretest and posttest obtained by students can be seen in the following figure.

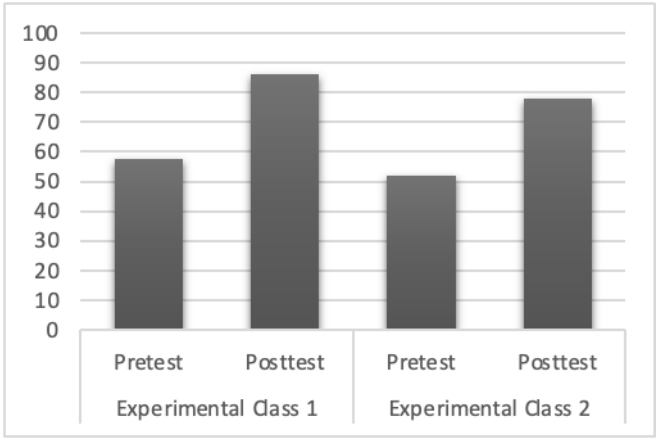

Figure 3. N-gain Values in Both Groups

The picture above shows that the experimental group 1 that applied the PjBL-STEM model got an N-gain score of 0.67, while the experimental group 2 that applied the PBL model got an N-gain of 0.54. Based on the results of the analysis, it can be stated that the increase in critical thinking skills in the experimental group that applied the PjBL-STEM model was greater than that applied the PBL model.

The results of the analysis on the significance of the difference in average improvement in students' critical thinking skills in the PjBL-STEM and PjBL groups can be seen in Table 4.

Tabel 4. Average Difference Significance Data

Class	N	Sig value count	Sig value 5%
Experimental 1	31	0.000	0.005
Experimental 2	28		

Based on Table 4, it can be stated that students in the PjBL-STEM group and those in the PjBL only group had significantly different average improvements in their critical thinking skills. From the results of the research, it can be concluded that the PjBL-STEM model is effective for improving the critical thinking skills of students. The results of this study are in line with the results of research conducted by Mulyani (2019), which states that STEM-based learning can facilitate students' use of multidisciplinary science in problem-solving and can train 21st-century skills, one of which is critical thinking skills. PjBL-STEM learning can encourage students to always be critical in their concept-finding and make a connection between their personal experiences and the content they are studying (Lestari et al. 2018).

Another research was also done by Widyasmah and Herlina (2020), which aimed to analyze the implementation of the STEM approach, which is focused on project-based learning to improve students' creative thinking. The study used mix methods or a combination of quantitative and qualitative research. The data obtained from this study is N-gain from the results of the pretest and posttest. N-gain data from pretest and posttest results can be seen in Table 5.

Table 5. N-gain Pretest and Posttest Results

Parameters	Pretest Score	Posttest Score	N-gain
Lowest score	30	55	0.1
Highest score	56	90	0.8
Standard deviation	9.75	8.84	0.13
Average score	51	73	0.4

Based on Table 5. It can be stated that the average N-gain is 0.4, which falls into the moderate category. This means that there is an increase from before getting treatment and after getting treatment by applying PjBL-STEM. Based on the results of the above research it can be concluded that learning with PBL-STEM is effective for improving critical thinking skills. These results are in line with the opinions expressed by Gandi et al. (2021), which states that PjBL-STEM has a good impact on improving students' critical thinking skills.

Based on the findings of some of the preceding studies, it is possible to conclude that PjBL-STEM is an effective method for improving students' critical thinking skills. This can be seen from the N-gain gained after being given treatment during learning in the form of PjBL-STEM in each study. PjBL-STEM can also be applied to various materials in physics, one of which is fluid dynamics.

PjBL-STEM is suitable for application in is fluid dynamics topic learning because it is by the basic competencies used. The basic competencies used in simple aircraft materials are found in KD 3.3 and KD 3.4. In this basic competency, it is expected that learners can create and test simple projects that apply the principles of fluid dynamics (Kemendikbud, 2018).

Based on this, because students are expected to be able to create and doing simple project, then one of the suitable learning models is PjBL. PjBL is one of the innovative learning models that can be applied in the learning process (Octaviyani et al., 2020; Wahyudi, 2021). PjBL is a learning model that emphasizes the learning process with an end result in the form of a product by making students the subject or learning center (Qadafi and Hastuti, 2022; Gandi et al., 2021).

Conclusion

The literature evaluation leads to the conclusion that using PjBL-STEM with fluid dynamics materials is appropriate for enhancing students' critical thinking abilities. According to the research analysis's findings, teaching that combines the PjBL-STEM approach is more efficient at improving students' critical thinking abilities. The N-gain gained when applying the PjBL-STEM model is usually higher, as can be observed from the comparison.

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Author Contribution
In this study, the authors made different contributions. Theoretical analysis, data collection, analysis, and paper writing were carried out by author 1, while supervision and writing review were done by authors 2 and 3.

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Conflicts of Interest
The authors declare no conflict of interest.

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