Systematic Literature Review: Critical Thinking Ability and Self-Efficacy in PBL Learning with STEM Approach

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Abstract

There are still many students who have not optimized their thinking ability, especially in higher order thinking and self-efficacy because students feel bored in learning mathematics. The learning model that fits student-centered is the Problem-based learning (PBL) model. PBL can be associated with STEM (Science, Technology, Engineering, and Mathematics). This study aims to compile and describe the study of mathematical critical thinking ability in Problem-Based Learning with the STEM Approach, Self-Efficacy in Problem-Based Learning with the STEM Approach, and correlation between Critical thinking ability and self-efficacy. The Systematic Literature Review (SLR) method was used in the writing of this article. This research was conducted by collecting, reviewing and concluding from several articles in the last 6 years (2017-2023). The results of this study show that problem-based learning may increase students' self-efficacy in studying mathematics and that it can improve students' critical thinking ability compared to conventional learning.

Keywords:

Critical thinking ability, Self-Efficacy, PBL, STEM.

1. Introduction

Mathematics is the basis or source of other sciences where the development of other sciences depends on mathematics. Mathematics is the main subject contained in the curriculum. The mathematics curriculum always changes according to the changing times and is required to be able to keep up with the times (Kusyanto et al., 2022). Mathematics as a universal science has an important role in various disciplines and to develop human thinking power (Andini, Winarti, & Mintarsih, 2022). In learning mathematics, one of the abilities that need to be developed is the ability to think critically.

Critical thinking ability is a cognitive process of students in analyzing problems carefully and thoroughly, as well as identifying and studying information to create problem-solving strategies in learning (Andini, Winarti, & Mintarsih, 2022). Critical thinking can be interpreted as a person's cognitive process to acquire mathematical knowledge which leads to drawing conclusions about what to believe and what actions to take (Noer & Gunowibowo, n.d.-a). Therefore, critical thinking can be interpreted as a thinking process in gathering information, interpreting, analyzing, evaluating, and drawing conclusions from a problem through the ability to reason and think reflectively based on evidence and logic that is believed to be true (Andini, Winarti, & Mintarsih, 2022).

In addition to the cognitive aspect, it is also necessary to improve the affective aspect, namely the psychological aspect related to students' attitudes as a support for success in learning, especially when dealing with critical thinking ability questions. Learning that does not interest students can result in low self-efficacy (Kusyanto et al., 2022). Self-efficacy in mathematics refers to the belief a student or person has in the ability they have to plan and carry out mathematics learning activities in order to achieve a certain goal by estimating the quantity of effort needed to reach that goal, which consists of the dimensions of magnitude, level, and strength.

(Kusyanto et al., 2022). With self-efficacy, students believe that they can solve problems or questions and can measure the extent to which their own abilities will understand, reason, analyze and work on a problem or problem. (Nurazizah et al., 2018).

Based on the preliminary study, according to (Nurazizah & Nurjaman, 2018), there are still many students who have not optimized their critical thinking skills, especially in high-level thinking and self-efficacy is still an obstacle. Students experience various levels of difficulty, starting with a lack of confidence in their abilities and assuming that their friends' abilities are better than what they have, they don't like their subjects, they don't understand the concepts being taught, they lack motivation in learning. According to (Listiani, Kadir, & Ruslan, 2017) indications of the causes of low mathematical thinking ability and students' self-efficacy in mathematics, they are students who feel bored in learning mathematics, students are passive in learning, students are not independent in constructing their knowledge and students are not trained to develop their thinking skills. This shows that it is not a field of study that is difficult to learn mathematics, but because the learning that is applied is not in accordance with the needs of students and the learning that takes place is not meaningful for students.

The results of the TIMSS (Trends in International Mathematics and Science Study) With an average score of 411, Indonesia placed 35th out of the 46 participating nations in 2003, while the global average score was 467. Indonesia is placed 36th out of 49 nations in the 2007 TIMSS study results, with an average score of 397, while the international average score is 500. As well as the 2011 TIMSS study results, Indonesia is ranked 38th out of 42 countries with an average score of 386, while the average score -international average 500 (Arifin, 2018).

In general, so far, the learning of mathematics has focused more on aspects of algorithmic calculations. So that there are not a few students who are generally able to perform various mathematical calculations, but do not show satisfactory results related to their application in everyday life. Learning mathematics should not only cover various mastery of algorithmic mathematical concepts. Applicable mathematical abilities such as presenting, analyzing, and solving real problems in everyday life (Arifin, 2018).

According to (Noer & Gunowibowo, n.d.-b) Learning mathematics with PBL-STEM is a form of learning that focuses students on real-life problems, the teacher's role is to present problems, ask questions and facilitate investigations. Therefore, the PBL model with the STEM approach is a learning that can help students in learning activities to develop activeness in investigative activities in an effort to solve problems, and is a learning model that allows students to develop critical thinking skills and self-efficacy.

The learning model that fits student-centered is the Problem-based learning (PBL) model (Andini, Winarti, & Mintarsih, 2022). Existing problems come from the realities around them and challenge students so that students are able to identify these problems with the aim of students understanding problems related to the lessons being delivered. The PBL model is implemented systematically based on this process, increasing the abilities of students through problem-solving, identification, and solutions provided in solving problems. (Hadi, 2021).

Science, technology, engineering, and mathematics (STEM) are four disciplines that work collaboratively to learn through problem-solving in everyday life. STEM is designed in a systematic way to provide solutions to problems in the learning process (Hadi, 2021). STEM learning in mathematics can facilitate students in mastering mathematical scientific content as well as mathematical critical thinking ability (Acar et al., 2018).

With research questions (1) Can students' critical thinking abilities increase by the STEM approach and problem-based learning model? (2) Can the problem-based learning model improve student self-efficacy? (3) How is the correlation between critical thinking ability and self-efficacy? Base on the description above, This study aims to review and discuss the research on mathematical critical thinking in problem-based learning with the STEM approach, self-efficacy in problem-based learning with the STEM approach, and the relationship between critical thinking capacity and self-efficacy.

2. Methods

This article was compiled using the Systematic Literature Review (SLR) method. A "systematic literature review" refers to a particular type of research or methodology used to gather and evaluate relevant research on a particular topic. (Triandini et al., 2019).

In general, the stages of research using the SLR method are as follows:

(1) Research Question (RQ), is a research question created depending on the requirements of the selected topic. The following questions relate to this research:
RQ1. Can students' critical thinking abilities increase by the STEM approach and problem-based learning model?
RQ2. Can the Problem-based learning model increase student self-efficacy?
RQ3. What is the correlation between critical thinking ability and self-efficacy?
(2) The search process, in particular, is used to find appropriate literature that answers the research question (RQ) and any related references.
(3) Exclusion and inclusion criteria. This process is used to determine if the data is appropriate for use in SLR research or not. The following are the study's inclusion and exclusion criteria:

Table 2. 1 Inclusion Exclusion Table

Inclusion	Exclusion
The data used is from the period 2017 to 2023.	The data used isn't from the period of 2017 to 2023.
The data used relates to the topic of self-efficacy and critical thinking abilities in problem-based learning and STEM approach.	Data are unrelated to the topic of critical thinking abilities and self-efficacy in problem-based learning with STEM approach.
The data used are in Indonesian and English	Data that is not in Indonesian or English

(4) Quality Assessment. The data collected in SLR research will be evaluated by applying the following quality assessment criteria questions:
QA1. Is the article published from 2017 to 2023?
QA2. Does the article mention the methodology or the objective of the research?
QA3. Does the article mention the learning model that was used?

Answers to the three QAs will be collected as either yes or no statements.

(5) Data collection, namely the process in which data are gathered for research. Primary and secondary data were gathered for this research.
(6) Data Analysis. The research question (RQ) will be used to analyze the data that has been gathered and collected.
(7) Deviation from the protocol. A change was made during the research process, especially to improve the database's search keywords' similar meanings.

3. Result and Discussion

3.1 Search Process results

To make it simpler to understand the type of data or journal type found through the search process, the search process results are categorized by journal type in Table 3.1.1.

Table 3. 1 Grouping by journal

No.	Journal Type	Quantity
1	Pasundan Journal of Matematics Education	1
2	PRISMA, Prosiding Seminar Nasional Matematika	2

3	Jurnal Pendidikan Indonesia (JPI)	2
4	Jurnal Penelitian Fisika dan Aplikasinya (JPFA)	1
5	JEMS (Jurnal Edukasi Matematika dan Sains)	1
6	JPD: Jurnal Pendidikan Dasar	1
7	Jurnal Pendas Mahakam	1
8	Jurnal Pendidikan Matematika	1
9	Jurnal Cendekia: Jurnal Pendidikan Matematika	1
10	JPMI: Jurnal Pembelajran Matematika Inovatif	2
11	Jurnal Cendekia: Jurnal Pendidikan Matematika	1
12	Pasundan Journal of Research in Mathematics Learning and Education	1 1
13	Journal of Science Education and Practice	1
14	Journal of Science Education Research	1
15	Jurnal Pendidikan Tambusai	1
16	Journal of Physics: Conferences Series	1
17	J-MPM: Jurnal Media Pendidikan Matematika	1
18	Jurnal Studi Guru dan Pembelajaran	1
	Total	22

3.2 Selection Results of Inclusion and Exclusion Criteria

The inclusion and exclusion criteria will be used in selecting the search results. 20 journals are left behind after this procedure, and data scanning is then carried out. Table 3.3.1 shows the results of the quality assessment to show whether or not the data were used in this research.

3.3 Results of Quality Assessment

Table 3. 2 Results of Quality Assessment

No	Writer	Year	QA1	QA2	QA3	Result
1	Kusyanto et al.	2022	Y	Y	X	✓
2	Andini, Winarti, & Mintarsih	2022	Y	Y	Y	✓
3	Saepuloh et al.	2021	Y	Y	Y	✓
4	Zulfawati et al.	2022	Y	Y	Y	✓
5	Putra et al.	2021	Y	Y	Y	✓
6	Oktavianingrum et al.	2020	Y	Y	Y	✓
7	Arifin	2018	Y	Y	Y	✓
8	Listiani et al.	2017	Y	Y	Y	✓

9	Nurazizah et al.	2018	Y	Y	X	✓
10	Negara et al.	2023	Y	Y	Y	✓
11	Saniah et al.	2022	Y	Y	Y	✓
12	Arum Setyorini et al.	2021	Y	Y	Y	✓
13	Octafianellis et al.	2021	Y	Y	Y	✓
14	Hadi.	2021	Y	Y	Y	✓
15	Purnamasari et al.	2020	Y	Y	Y	✓
16	Vina Hari et al.	2018	Y	Y	X	✓
17	Wahyuni et al.	2022	Y	Y	Y	✓
18	Marifah	2023	Y	Y	Y	✓
19	Evi & Indarini	2021	Y	Y	Y	✓
20	Ritonga	2021	Y	Y	X	✓

Symbol description:

- ✓ : For journals or data used in research. The data was chosen because it has problems, approaches, and sufficient information for data selection.
- × : For journals or data that are not used in research because the data are articles written by guest editors that inform about the experiences of researchers, problems, approaches, or insufficient information for data selection.

3.4 Data analysis

This stage will answer questions from the Research Question (RQ)

3.4.1 Discussion of Results

RQ1. Can students' critical thinking abilities increase by the STEM approach and problem-based learning model?

Based on the results of previous research in the articles that have been collected in this study, it may be concluded that the STEM approach with a problem-based learning model increases the ability of learners to think critically compared to conventional learning. The researcher's opinion is supported by the opinion of previous researchers such as (Andini, Winarti, & Mintarsih, 2022), (Setyorini et al., 2021), (Octafianellis et al., 2021), (Hadi, 2021), dan (Zulfawati et al., 2022). (Kusyanto et al., 2022) in his article explained that during the learning process students with the STEM approach were very active in finding and solving problems through group discussions and in class discussions. During the learning process students can also find out about problems and determine ways that can be used to deal with problems.

There are several stages of implementing the PBL model in learning. Each phase characterizes a student-centered thinking process and the teacher as a facilitator. The following is the syntax of the PBL learning model:

Table 3. 3 PBL Learning Model Syntax

Phase	Indicator	Teacher Activities
1	Problem orientation	The teacher encourages students to participate in problem-solving activities, explaining the learning objectives and necessary practicalities, and motivating them to do so.
2	Organizing students to study	The teacher helps students to define and organize learning tasks relevant to these problems.
3	Guiding and investigating individuals and groups	The teacher encourages students to gather relevant information, carry out experiments to obtain explanations and solve problems.
4	Develop and present the work	The teacher helps students with various assignments with their peers and with the planning and preparation of appropriate works, such as reports.
5	Analyze and evaluate the problem-solving process	Help students to reflect or evaluate their investigations and the processes they use.

Mustofa et al., (2021) states that the STEM-based PBL learning model can improve students' critical thinking ability because in this learning model students are required to identify problems then analyze these problems and then discuss with their groups to be able to provide an evaluation of these problems. In addition, learning STEM could help students in solving problems and determining conclusions from the learning that has been done with the application of STEM so that students can obtain increasingly advanced knowledge on problems happening in real life to improve their critical thinking ability.

RQ2. Can the problem-based learning model increase student self-efficacy?

Arifin, (2018) in his article reveals that the application of the problem-based learning model can increase students' self-efficacy in learning mathematics. This opinion is supported by opinions from other studies such as (Listiani et al., 2017), (Negara et al., 2023, (Saniah et al., n.d. 2022), (Zulfawati et al., 2022). (Listiani et al., (2017) stated that students who used contextual problem-based learning models had significant increases in their math self-efficacy compared to those who used

direct learning models. Students who used the problem-based learning model had a significant increase in their mathematical self-efficacy compared to students who applied the direct learning model. Meanwhile, according to (Kusyanto et al., 2022) students' self-efficacy in the STEM approach is lower than the conventional approach because the individual abilities in the class that get the conventional approach have confidence in the results they get, while the class that gets the STEM approach has low confidence in achieving good grades so they ask their friends for help, for fear of getting a low score causes them to be unsure of the results of the answers they have. But this is not caused by the wrong STEM approach, but from the individual. But in classes that get the STEM approach students become very active in asking questions and group discussions.

RQ3. What is the correlation between critical thinking ability and self-efficacy?
According to (Nurazizah et al., 2018) found that junior high school students' critical thinking abilities and self-efficacy have correlations in the material circle. This is not in line with research conducted by (Putra et al., 2021) indicates there is a significant variance between the self-efficacy category's level and mathematical critical thinking ability. Students who have moderate self-efficacy gain critical thinking ability that are as good as students who have low self-efficacy. This is in line with research conducted by (Kusyanto et al., 2022) in his research stated that there was no relationship between critical thinking ability and students' self-efficacy. Although students' critical thinking abilities have improved, they lack self-confidence when trying to solve math problems, which leads to a low relationship between critical thinking abilities and student self-efficacy. Because students lack confidence in their abilities to solve problems it may be stated that there is no relationship between self-efficacy and students' critical thinking abilities, even though the fact that students' critical thinking skills have increased.

4. Conclusion

According to the research results of the review, it can be concluded that. (1) The problem-based learning model with the STEM approach can improve students' critical thinking ability compared to using conventional learning models, (2) Some studies state that student self-efficacy has increased by using the problem-based learning model, but there are also those who state that the self-efficacy of students who applied the PBL model and the STEM approach was low, but it was not wrong from the approach but from the individual, (3) Because students lacked confidence in their ability to solve problems there was no correlation between self-efficacy and critical thinking abilities, although there was an increase in their ability to think critically. Further research is needed on the topic of critical thinking ability and self-efficacy in problem-based learning with the STEM approach.

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