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Scoping Literature Review of STEM Research in Indonesia in Improving Critical Thinking Skills and Concepts Mastery

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Abstrak

Publikasi artikel sebelumnya tentang penelitian STEM masih sebatas mendeskripsikan dampak STEM terhadap pembelajaran dan tidak memberikan informasi spesifik tentang kompetensi tertentu. Selain itu, publikasi tersebut masih terbatas pada satu jenjang pendidikan dan mata pelajaran sebagai kriteria sampel. Penelitian ini bertujuan untuk menganalisis literatur penelitian STEM di Indonesia dalam meningkatkan kemampuan berpikir kritis dan penguasaan konsep pada mata pelajaran kimia, fisika, biologi, dan sains dari tingkat pendidikan dasar hingga perguruan tinggi, merangkum dan menyebarluaskan berbagai pilihan literatur. Metode penelitian meliputi mengidentifikasi pertanyaan penelitian, mengidentifikasi studi yang relevan dengan mencari artikel penelitian di jurnal dan artikel konferensi dalam prosiding dengan kata kunci tertentu, memilih studi berdasarkan kriteria, memetakan data, kemudian menyusun, meringkas, dan melaporkan hasilnya. Setelah itu charting data adalah mensintesis dan menginterpretasikan data kualitatif dengan cara menyaring, memetakan, dan menyortir materi sesuai isu dan tema utama. Temuan dari analisis ini adalah penelitian STEM didominasi oleh penggunaan metode eksperimen (53,33%), STEM sebagai pendekatan pembelajaran (71,1%), dan terutama PjBL (24,44) dan PBL (17,78%). Penelitian STEM terkait pembelajaran dan pengembangan perangkat pembelajaran berbasis model pembelajaran selain PjBL dan PBL belum banyak dilakukan.

***Kata kunci*:** *Penguasaan Konsep, Keterampilan Berpikir Kritis,* Scoping Literature Review, *STEM*

Abstract

The publication of previous articles on STEM research was still limited to describing the impact of STEM on learning and did not provide specific information on certain competencies. In addition, these publications are still limited to one level of education and subjects as sample criteria. This study aims to analyze the literature on STEM research in Indonesia in improving critical thinking skills and concepts mastery in chemistry, physics, biology, and science subjects from elementary to tertiary education levels, summarizing and disseminating a wide selection of literature. Research methods include identifying research questions, identifying relevant studies by searching for research articles in journals and conference articles in proceedings with certain keywords, selecting studies based on criteria, mapping data, then compiling, summarizing, and reporting the results. After that charting the data is synthesizing and interpreting qualitative data by sifting, charting, and sorting material according to key issues and themes. The findings from this analysis are that STEM research is dominated by the use of experimental methods (53.33%), STEM as a learning approach (71.1%), and especially PjBL (24.44) and PBL (17.78%). STEM research related to learning and developing learning tools based on learning models other than PjBL and PBL has not been done much.

Keywords: Concepts Mastery, Critical Thinking Skills, Scoping Literature Review, STEM

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1. INTRODUCTION

The development of science in the 21st century requires a person to be a quality human resource by mastering critical thinking skills. Critical thinking skills are part of cognitive skills in STEM competencies which involve mental processes in understanding something through thinking and practicing (Munoto, 2018; Ng, 2019). Critical thinking skills use an inductive or deductive approach to identify facts and phenomena, think systematically, and have sensitivity to strategic issues. Therefore, STEM education needs to implement in science learning. STEM stands for Science, Technology, Engineering, and Mathematics. STEM education encourages students to make new and productive connections in various disciplines, one of which can be proven by increasing learning outcomes (Fatimah &

Santiana, 2017; Winarni et al., 2016). It is following the essence of STEM is to use science, mathematics, technology, and engineering to solve social or everyday problems and make learning more meaningful and contextual so that students will be trained to think critically (Kang, 2019; Torlakson, 2014). STEM also can prepare students to become quality citizens and workforce.

STEM education is implemented in many countries. It evidenced by the many studies on STEM from various fields, such as economics, human resource management, and education. However, STEM research in education, especially scoping literature review on the study of STEM integration in learning has not been identified even though it is essential to know so that researchers can develop and conduct research related to STEM. A systematic literature review of STEM research showed that most of the publications in STEM education research were conducted by researchers from the United States, Australia, Canada, and Taiwan (Li et al., 2020). Researchers from countries on the Asian continent have also begun to research STEM topics for several years around 2019. The topic of STEM research in Indonesia is dominated by a learning model under experimental methods, using STEM-PjBL as a form of integration, and the dominant dependent variables associated with STEM learning are mastery concepts and scientific literacy (Ardwiyanti et al., 2021). It is in line with the finding of other study that STEM is most often integrated as a learning model, a research subject dominated by students in East Java and West Java senior high schools (Farwati et al., 2021). The review results in those publications still do not describe specific information on certain competencies.

The result of the systematic literature review conducted shows the implementation of STEM in mathematics and science learning give a positive impact on students, including basic questioning skills, concept understanding, creative thinking skills, critical thinking skills, information, media and technology capabilities, learning achievement, life and professional abilities, motivation, problem-solving, and scientific literacy (Nursyahidah & Mulyaningrum, 2022). Then, the result of the meta-analysis conducted by previous study shows that STEM integration using Project Based Learning (PjBL) contributes impact to learning outcomes including conceptual understanding, motivation, and 21st-century skills (Khoiri, 2019). This finding is supported by the result of a review state that STEM-PjBL give a positive and significant impact on students' critical thinking skills at elementary school, junior high school, and senior high school (Setyawati et al., 2022). Those researches are limited to describing the impact of STEM on learning.

The result of a review conducted by other study shows STEM research methods in education are dominated by survey-based research, but the sample is not specified articles about STEM-integrated learning in certain disciplines for certain levels and the impact on certain competencies (Takeuchi et al., 2020). The findings of the systematic literature review of previous study show many researchers have a substantial interest in developing STEM-based teaching and learning materials, but it is limited to research in elementary schools as sample criteria (Nuraeni et al., 2020). This limitation was also found in the review conducted which shows that most articles on critical thinking skills were published in 2020 using a quantitative approach, quasi-experimental design, test instruments, and descriptive statistical data analysis techniques (Juliyantika & Batubara, 2022). The most frequently researched elementary school subject is Mathematics and Natural Sciences in grade 5th. The trend of critical thinking skills research has also been carried out who found the most research using quantitative research with students in grade 10th as a research subject to learn ecosystem material through a problem-based learning model, but this review specifically on biology subject (Susetyarini & Fauzi, 2020).

Based on tracking information via the internet and reviewing the results of previous reviews, it can be seen that a scoping literature review on STEM research topics in Indonesia

in improving critical thinking skills and concepts mastery has never been carried out. This study aims to analyze literature on STEM research in Indonesia in improving critical thinking skills and concepts mastery, to summarize and disseminate a broad selection of reviewing articles published in national and international journals and seminar proceedings.

2. METHODS

This research type is a scoping literature reviews which to analyze literature on STEM research in Indonesia in improving critical thinking skills and concepts mastery, to summarize and disseminate a broad selection of literature. The procedure of this research follows five stages of a framework for conducting a scoping review including (1) identifying the research questions, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the result (Arksey & O'Malley, 2005).

The research questions in this scoping literature review were identified to describe research methods, topics, and forms of integration of STEM into science learning (Chemistry, Biology, Physics, and Science) which are most often used in STEM research to improve critical thinking skills and mastery of concept in Indonesia. In addition, It also identified discovered potential future research topics related to STEM. This scoping review was obtained articles from Google Scholar by searching with the keyword "STEM to improve critical thinking skills in Indonesia", "STEM to improve mastery of concept in Indonesia", and "STEM to improve conceptual mastery in Indonesia". Article documents consist of national and international research articles in journals and conference articles in proceedings. Study selection is the stage for selecting relevant research articles. This selection is determined based on the criteria in Table 1.

Table 1. Research Sample Criteria

Specification	Criteria
Publication type	Research articles published in the journal and conference articles in the proceeding indexed minimal Sinta (national) and Copernicus (international)
Year of Publication	2018-2022
Research Place	Indonesia
Authors' Nationality	Indonesia and a combination of Indonesia and abroad
Independent Variable	Integration of STEM in learning to improve critical thinking skills and concepts mastery
Research Field	Biology, chemistry, physic, and science
Research Subject	Students at the Elementary School, Junior High School, and Senior High School levels, as well as students at tertiary institutions

Based on a search for research samples on the internet, we found 45 articles related to STEM research in improving critical thinking skills and concepts mastery in Indonesia as shown in Table 2.

Table 2. Research Samples based on Journal Identity.

Index	Journal/ Proceeding Name	Number of Publication
Scopus (not yet Quartile/	Journal of Physics: Conference Series (Agustina & Dwikoranto, 2021; Hartini et al., 2020; Parno	8

Index	Journal/ Proceeding Name	Number of Publication
Q)	et al., 2022; Parno, Fauziyah, et al., 2021; Parno, Supriana, et al., 2021; Purnamasari et al., 2020; Sari et al., 2020; Yulianti et al., 2020)	
	AIP Conference Proceedings (Ananda et al., 2021; Purwaningsih et al., 2020; Rahmawati et al., 2021; Zakiyah et al., 2021)	4
Copernicus	International Journal of Innovative Science and Research Technology (Sutoyo et al., 2019)	1
	International Journal of Progressive Sciences and Technologies (Agustin et al., 2020)	1
	Journal for the Education of Gifted Young Scientists (Isdianti et al., 2021)	1
Sinta 1 and Scopus Q2	Jurnal Pendidikan IPA Indonesia (Mutakinati et al., 2018)	1
Sinta 2	Jurnal Penelitian dan Pengembangan Pendidikan (Setiani et al., 2021)	1
	Jurnal Ilmu Pendidikan (Prastika et al., 2022)	1
	Jurnal Pendidikan Kimia Indonesia (Ningkaula et al., 2021)	1
	Journal of Educational Science and Technology (Bili et al., 2022; Madyani et al., 2019; Mardita et al., 2022)	3
	Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan (Khotimah et al., 2020; Nisa et al., 2020; Rivai et al., 2018; Yulaikah et al., 2022)	4
	Jurnal Inovasi Pendidikan IPA (Allanta & Puspita, 2021)	1
Sinta 3	Journal of Chemistry Education Research (Fatayah et al., 2022)	1
	Journal of Educational Chemistry (Oktaviani et al., 2020)	1
	Journal of Science Education Research (Indriyana & Susilowati, 2020; Octafianellis et al., 2021)	2
	Jurnal Pembelajaran Fisika (Ulfa et al., 2021)	1
	Jurnal Pembelajaran Kimia (Sumarni et al., 2019)	1
	Quagga: Jurnal Pendidikan dan Biologi (Afifah et al., 2019; Astuti et al., 2019)	2
	Journal of Innovative Science Education (Isro et al., 2021)	1
Sinta 4	ALOTROP: Jurnal Pendidikan dan Ilmu Kimia (Tripripa et al., 2020)	1
	Jurnal Ilmu Pendidikan Indonesia (Laisnima & Siregar, 2020)	1
	Jurnal Pendidikan Fisika dan Teknologi (Rahmana et al., 2022)	1
	Jurnal Riset Pendidikan Fisika (Kholil et al., 2022)	1
	Pancasakti Science Education Journal (Rizkika et al., 2022)	1
	PENDIPA: Journal of Science Education (Ningrum et al., 2022)	1

Index	Journal/ Proceeding Name	Number of Publication
Sinta 5	Journal of Science Education and Practice (Pramuji et al., 2018; Setyorini et al., 2021)	2
	Jurnal Sains dan Pendidikan Fisika (Suardi, 2020)	1
	Total	**45**

After that charting the data is synthesizing and interpreting qualitative data by sifting, charting, and sorting material according to key issues and themes. The data were entered using the Excel program (Arksey & O'Malley, 2005). The data will be a mixture of general and specific information as follow (1) year, author, and nationality, (2) name and index of the journal, (3) title of article, (4) research field, method, and topic, (5) STEM-integrated form, and (6) important results. The assessment was carried out on research methods, results, discussion, and conclusions contained in the article. Data were analyzed using calculations in the form of percentages where the data is divided by the amount of data in one component and then multiplied by 100 percent.

3. RESULTS AND DISCUSSION

Results

STEM Research Methods in Indonesia

STEM research methods in Indonesia to improve critical thinking skills and concepts mastery are relatively varied. The results of a systematic literature review are presented in Table 3 which contains STEM research methods in Indonesia in improving critical thinking skills and mastery of concepts classified based on the research approach.

Table 3. Research Methods

Research Approach	Research Method	Percentage
Quantitative	Experiment	53.33%
Qualitative	aNarrative Inquiry	2.22%
	Research and Development	22.22%
	Mixed Method	15.57%
Others	Descriptive Analysis	2.22%
	Qualitative Descriptive	2.22%
	PTK Cycle	2.22%

STEM Research Topics

STEM research in Indonesia in improving critical thinking skills and concepts mastery is carried out in various ways, such as integrating it as an approach or learning device as presented in Table 4. Learning devices that integrated STEM is showed in Table 5.

Table 4. Research Topics

Research Topics	Percentage
Approach	71.1%
Learning Device	28.9%

Table 5. Learning Devices Developed or Used in Research

Learning Devices	Percentage
Module	15.56%
Student Worksheet	11.11%
Interactive Media	2.22%

Forms of STEM Integration

Table 6 contains form of STEM integration as approach to implement learning model in STEM research in Indonesia to improve critical thinking skills and concepts mastery.

Table 6. Forms of STEM Integration

Form of STEM Integration	Percentage
STEM-Project Based Learning (PjBL)	24.44%
STEM-Problem Based Learning (PBL)	17.78%
STEM-Inkuiri	8.90%
STEM-Learning Cycle 5E	4.44%
STEM-Learning Cycle 7E	2.22%
STEM-Model Instruction	2.22%
STEM-MIKiR	2.22%
STEM-Discovery Learning	2.22%
STEM-Contextual Problem	2.22%
STEM-PTK Cycle	2.22%
STEM-Integrated Learning	2.22%
Total	**71.1%**

Discussion

STEM Research Methods in Indonesia

Trends in the STEM research approach in Indonesia consist of a quantitative approach (24 studies), qualitative (1 study), and others (20 studies). The findings of the dominant approach used in research are by assistance (Susetyarini & Fauzi, 2020). The often research method used is the experimental method (24 studies), according to the findings of research and development (10 studies), and mixed methods (7 studies) (Juliyantika & Batubara, 2022; Susetyarini & Fauzi, 2020). It supports the research results state that STEM research methods in Indonesia are dominated by experimental methods, mixed methods, then narrative inquiry when viewed from each successive approach (Ardwiyanti et al., 2021).

STEM research in Indonesia in improving critical thinking skills and concepts mastery is dominated by research using the experimental method, where this method consists of quasi-experiments; 2×2 factorial design, and non-equivalent control group design, as well as pre-experimental; one-shot case study and one group pretest-posttest design. Most Indonesian researchers in the field of integrated STEM education use the experimental method because it can show the results of STEM integration treatment in learning.

Indonesian researchers conduct research using scientific methods. The scientific method initially involves systematic observation, finds interconnected ideas, then is tested by observation (Cohen et al., 2018). Usually, Indonesian education researchers conduct initial research to find problems. This problem becomes the background for preparing hypotheses, research design, drawing conclusions, and reporting research results. Therefore, most Indonesian researchers are positivists.

STEM Research Topics

The research topic is the main idea of the research. The use of STEM in Indonesia in improving critical thinking skills and conceptual mastery is an interesting matter to study from various sides as a research topic. Enhancing STEM education requires teachers' capacity including adequate content and pedagogical knowledge (Kelley & Knowles, 2016; Murphy et al., 2019; Yildirim, 2016). In STEM education, teachers should strive to design lessons that generate connections between STEM subjects and provide relevant contexts for learning content (Kelley & Knowles, 2016). STEM can integrate into learning as an approach in general or certain learning models/ strategies or integrate into learning devices. Giving treatment helps identify the effect of certain factors on the parameters investigated by previous study for example, integrating STEM as a learning approach to improve critical thinking skills and learning outcomes (Susetyarini & Fauzi, 2020).

STEM research topics in Indonesia in improving critical thinking skills and concepts mastery dominated by approaches (32 studies). The finding of the most STEM research topics in Indonesia in improving critical thinking skills and concepts mastery following the results of a systematic review that STEM research topics in Indonesia are dominated by learning strategies (Ardwiyanti et al., 2021). This is also supported by the findings of study that more research focuses on STEM-based learning practices (Nuraeni et al., 2020). Researchers like to conduct integration of STEM as learning approach because integration of STEM makes learning more contextual and meaningful which helps students solve problems. According to the concepts learned through a critical thinking process (Parameswari & Azizah, 2020). STEM research topic in Indonesia also integrates STEM into learning devices (13 studies). STEM-integrated learning devices are used to support learning as a means of student interaction (Nuraeni et al., 2020; Sutoyo et al., 2019). STEM-integrated learning devices could build knowledge, attitudes, and skills through scientific observation and discussion so that students have direct experience to solve problems (Ozdamli & Ozdal, 2018; Yulianti et al., 2020).

Based on a review of research samples, it can be seen that STEM is often integrated as a learning approach to improve critical thinking skills and concepts mastery through research using experimental and mixed methods. Learning devices that integrate STEM consist of modules, Student Worksheets, and interactive multimedia as shown in Table 5. There is 1 study each using pre-experimental method, quantitative descriptive, and mixed method that integrate STEM in learning devices, as well as 10 studies using research and development method.

Form of STEM Integration

STEM education consists of 4 disciplines in an interdisciplinary approach which can be learned through an integrated approach. Based on it can be seen that STEM is most integrated into learning with the PjBL model (11 studies) and PBL model (8 studies) to improve critical thinking skills and concepts mastery. This finding supports the findings of that the integration of STEM in learning is dominated by STEM-PjBL and STEM-PBL (Ardwiyanti et al., 2021) and is supported by the findings that state critical thinking skills are often trained through the PBL (Susetyarini & Fauzi, 2020).

The PBL model syntax consists of phases (1) problem orientation, (2) grouping students, (3) investigation, (4) development and presentation, and (5) analysis and evaluation. According to previous studies the PjBL model consists of phases (1) Reflection, (2) Research, (3) Discovery, (4) Application, and (5) Communication (Ningrum et al., 2022; Rahmawati et al., 2021). While the other syntax consists of 6 phases including (1) Start the essential question, (2) Design project, (3) Create a schedule, (4) Monitoring the students and

progress of the project, (5) Assess the outcome, and (6) Evaluation of the experience (Allanta & Puspita, 2021; Sumarni et al., 2019; Yulaikah et al., 2022).

Based on the analysis of STEM research trends in Indonesia in improving critical thinking skills and concepts mastery, any recommendations are proposed for research in the future, as follows (1) STEM research with methods other than experiments through learning other than STEM-PBL and STEM-PjBL and (2) STEM research through the development of STEM-based learning devices and learning model syntax other than PBL and PjBL.

This study has several limitations. First, the data is limited to articles in scientific journals and proceedings that are indexed nationally at least in Sinta and internationally at least in Copernicus. Second, the sample search strategy with predetermined criteria caused missed relevant research published in theses and dissertations not used. Third, articles in journals and proceedings used in the scoping literature review are limited to the field of education. Fourth, the research sample is limited to the scope of research on STEM-integrated learning to improve critical thinking skills and mastery of concepts in Indonesia. Based on those findings, it can provide a generalization that STEM researches in Indonesia in improving critical thinking skills and mastery of concepts is dominated by research that uses experimental methods with STEM approach research topics which integrated into PBL and PjBL models. STEM research related to learning and developing learning tools based on learning models other than PBL and PjBL has not been done much.

4. CONCLUSION

The meaning and impact of this scoping literature review is STEM integration in learning can improve critical thinking skills and learning outcomes. This finding can be used by teachers as suggestions for STEM-integrated learning to improve students' critical thinking skills and learning outcomes and for researchers to conduct research that supports STEM integration in learning. This scoping literature review is limited to research samples on STEM integration in improving critical thinking skills and mastery of concepts in Indonesia with data from articles in scientific journals and proceedings that are indexed nationally at a minimum Sinta and internationally at a minimum Copernicus. Therefore, the suggested future research is scoping the STEM integration literature review to improve the scientific process, creative thinking, problem solving, argumentation skills, and scientific literacy using data sources from Google Scholar-indexed journals.

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