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MATHEMATICAL CRITICAL THINKING ABILITY IN INDONESIA: SYSTEMATIC LITERATURE REVIEW (SLR)

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ABSTRACT

Mathematical critical thinking ability is one of the skills contained in 4C competencies that 21st-century students must possess. Many studies related to mathematical critical thinking skills have been carried out. The purpose of this research is to find out how the heterogeneity of studies related to the analysis of mathematical critical thinking skills in Indonesia based on the year of publication, education level, grade level, publication in journals indexed by sinta, the subject matter used in research, demographics, and indicators of critical thinking ability. The method used in this study is a Systematic Literature Review (SLR) based on a quantitative descriptive approach using the PRISM protocol, including the identification, screening, eligibility, and included stages. The results of the SLR research show that research related to the analysis of mathematical critical thinking skills with a qualitative approach was most published in 2021 and 2022. Most studies are carried out at the junior high school level with the subject of research of 7th and 8th graders in the branch of algebraic mathematics. The Java region dominates research on mathematical critical thinking skills with a qualitative approach of 73%, most widely published in Sinta 4 indexed journals. The indicators of critical thinking skills that students haven't mastered were providing arguments or reasons in answering and drawing conclusions appropriately according to the context of the problem.

Keyword : Mathematical Critical Thinking Ability, Systematic Literature Review

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INTRODUCTION

In the 21st century, education integrates knowledge, skills, attitudes, and mastery of technology and information. Students must possess 4C competencies: critical thinking and problem-solving, creativity, communication skills, and working collaboratively. (Kemdikbud, 2019), (P21, 2007). It is according to the Minister of Education and Culture's Regulation No. 20 of 2016 on Competency Standards for Primary and Secondary Education Graduates, each graduate of primary and secondary school education units must possess six competencies., namely: (1) Creative, (2) Productive, (3) Critical, (4) Independent, (5) Collaborative, (6) Communicative (Permendikbud, 2016). Based on this description, mathematical critical thinking abilities need more attention.

Critical thinking skills are self-regulation in making decisions that involve interpretation, analysis, evaluation, and inference, as well as exposure to evidence, concepts, methodologies, or contextual factors that serve as the basis for conclusions/statements. (P. A. Facione, 1991) (Lipman, 1987). According to Ennis, the definition of critical thinking is reasonable and reflective thinking that focuses on what is believed or done (Ennis, 1996). According to Belecina and Ocampo (2018), critical thinking is a disciplined cognitive process that involves actively and skillfully conceptualizing, applying, analyzing,

synthesizing, and evaluating information that has been obtained or generated through observation, experience, reflection, reasoning, or communication as a model for attitudes and actions. (Belecina, 2018). In addition, according to Chukwuywnum, critical thinking skills are one of the tools used in everyday life to face challenges in survival (Chukwuyenum, 2013). So that critical thinking ability is the ability to think logically and systematically in making decisions or solving a problem.

Ennis claimed that there are 12 indicators of critical thinking skills, which are broken down into five stages, including: (1) the basic clarification stage, which involves formulating questions, analyzing arguments, asking and answering questions, (2) In addition making observations and evaluating reports of observations, the stages of providing reasons for a decision (the bases for the decision) also include evaluating the reliability of information sources. (3) The stages of concluding (inference) include drawing deductions and evaluating them, drawing inductions and evaluating them, and evaluating (4) Additional Clarification Stages (Advanced Clarification): Define and Evaluate Definitions, Identify Assumptions, (5) The stages of speculation and integration involve both speculating and integrating (Ennis, 1996). Faccione (P. A. Facione, 2011) lists six indicators of critical thinking skills, including: (1) interpretation is the process of comprehending and articulating the significance of a variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria; (2) Analysis is the process of figuring out how assumptions, questions, concepts, descriptions, or other types of representation that express an opinion, belief, experiences, reasons, or other types of representation relate to one another in reality. (3) Evaluation determines the veracity of claims or other representations that are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion. It is the process of determining the strength of the logical relationships between claims, descriptions, questions, or other forms of representation that are actually or deliberately implied. (4) Inference is the process of identifying and securing the components necessary to reach reasonable conclusions, formulating conjectures and hypotheses, taking into account relevant information, and minimizing the effects of data, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation. (5) Explanation is the ability to present the results of one's reasoning logically and coherently. (6) Self-regulation refers to the conscious observation of one's cognitive processes, the inputs used in those processes, and the conclusions are drawn. It is accomplished primarily by applying analytical and evaluative skills to inferential judgments to challenge, validate, or correct one's conclusions or reasoning. A critical thinker can ask the right questions, gather pertinent information, organize it creatively and efficiently, apply logic, and draw valid conclusions about the world that allow them to live and act successfully. (Schafersman, 1991). Given the importance of critical thinking skills, these abilities must be developed from the elementary school level and need attention from educators and researchers.

Numerous previous researchers have conducted research on mathematical critical thinking skills, including (Sumargiyani et al., 2021)**;** (Setiana & Purwoko, 2020)**;** (Andriawan et al., 2018)**;** (Fauzi et al., 2020)**;** (Prajono et al. 2022) and other studies. To obtain complete information and appropriate data, we need to comprehensively review how the description of research related to mathematical critical thinking skills in learning, especially research carried out in Indonesia. Therefore, the research was conducted as a systematic review using the systematic literature review (SLR) method. A systematic review is a summary of the body of research that has been done on a particular issue. It is conducted to locate, pick out, evaluate, and synthesize all credible research data pertinent to that question. (Cronin, 2013). The primary goal of this Systematic Literature Review (SLR) is to

find out how the heterogeneity of studies related to the analysis of mathematical critical thinking skills in Indonesia based on the year of publication, education level, grade level, indexing by sinta, the subject matter used in research, demography and indicators of critical thinking ability. Thus, The researcher poses the subsequent relevant questions: (1) What is the trend of publications related to critical thinking skills analysis in Indonesia based on the year of publication? (2) What is the trend of publications related to critical thinking skills analysis in Indonesia based on education level? (3) At which grade level (subject of research) is there a lot of research related to the analysis of critical thinking skills? (4) How is the trend of publications related to the analysis of critical thinking skills in Indonesia based on publications in sinta indexed journals? (5) Which branch of mathematics is most widely used in critical thinking skills analysis research in Indonesia? (6) What is the trend of publications related to critical thinking skills analysis in Indonesia based on demographics? (7) Which indicators of critical thinking ability are found out the most that haven't been mastered by students?

METHOD

Research Design

The design of this study is a *Systematic Literature Review* (SLR). A systematic literature review is a type of secondary research that employs a transparent methodology to locate, assess, and interpret all evidence relevant to a given research question in a fair and (to a certain extent) repeatable manner. A systematic literature review is a formal method of combining data from primary studies pertinent to research questions. (Kofod-petersen, 2018). This method uses a descriptive quantitative approach (Litte et al., 2008). This research procedure includes collecting, analyzing, and concluding (Juandi & Tamur, 2020). The keyword was "Analisis Kemampuan Berpikir Kritis" All the data collected is primary data published as an article and national journal registered and indexed by Sinta. The next step is to the articles sorted by inclusion criteria. Only relevant articles that fulfil the inclusion criteria will be used in the Study (Juandi & Tamur, 2020), (Jesson et al., 2011).

Inclusion Criteria

The inclusion criteria utilized in this research were: (1) the study evaluated mathematics education; (2) the study is written in Indonesian; (3) the study analyzed mathematical critical thinking ability in Indonesia in the period 2013 to 2022; (4) The method of study must use Qualitative Approach; (5) The Study includes education level from elementary until university level; (6) Study indexed by Sinta; (7) The Study contained teaching materials that used in research. The articles that didn't fulfil the inclusion criteria were eliminated from analyzing process.

Data Collection Technique

The populations in this study use a qualitative approach and focus on analyzing mathematical critical thinking ability in Indonesia. The search engines used to gather information are Publish or Perish, Google, and Google Scholar with the keyword "Analisis Kemampuan Berpikir Kritis." Based on a preliminary search, 401 articles discussed critical thinking ability. The entire article was sorted, and 60 papers are pertinent and meet the criteria for inclusion. The protocol of this Study is PRISM. The selection process was conducted with 4 phases: identification, screening, eligibility, and included (Juandi & Tamur, 2020), (Liberati et al., 2009). The process of the selection of articles is presented in the diagram of the prism below.

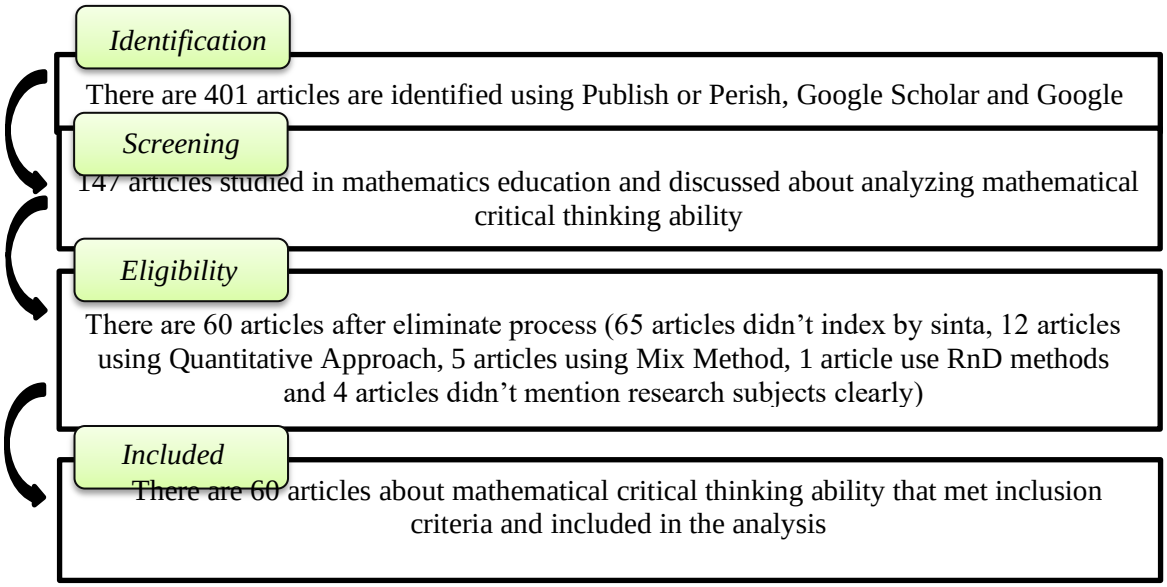


Figure 1. The diagram of PRISM for mathematical critical thinking ability

RESULTS AND DISCUSSION

The result presented in 6 parts includes the year of publication, education level, research subjects, journal indexing, teaching materials used in research, and research location. The analysis result based on six criteria is presented in Table 1 below

Table 1. The results of the analysis of the articles based on six criteria

Characteristic Study	Criteria	Frequency
Year of Publication	2013 – 2015	0
	2016	2
	2017	1
	2018	14
	2019	7
	2020	6
	2021	15
	2022	15
Education Level	SD	1
	SMP	31
	SMA	21
	University	7
Research Subject	V	1
	VI	0
	VII	14
	VIII	13
	IX	5
	X	8
	XI	9
	XII	3
	Semester 1	2
	Semester 3	1
	Semester 4	1
	Semester 5	1
	Semester 6	2
Research Location	Sumatera	8
	Jawa	44
	Kalimantan	1
	Sulawesi	5
	Bali dan Nusa Tenggara	2
Journal Indexing	S6	2
	S5	14
	S4	33
	S3	7
	S2	4
	S1	0

Teaching Materials	Algebra	24
	Geometry	19
	Calculus	4
	Statistics	2
	Arithmetic	10
	Analysis	1

Study Based on Year of Publication

The details of the preliminary dissemination study from 2013 to 2022 are presented in Figure 2

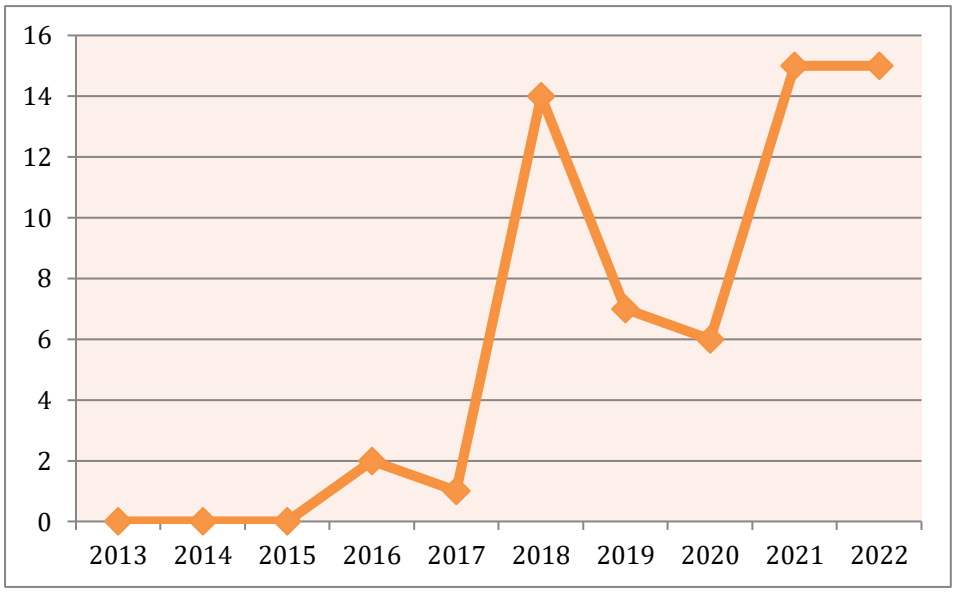


Figure 2.The study by Year of Publication

Figure 2 shows that research about mathematical critical thinking ability has increased yearly in the last ten years, from 2016 to 2022. In addition, research on mathematical critical thinking ability in Indonesia increased from 2017 to 2018 and decreased from 2019 to 2020 as the effect of covid-19 but increased again in 2021. The studies about analyzing mathematical critical thinking ability using a qualitative approach were published the most in 2021 and 2022, each with as many as 15 articles.

Study Based on Education Level

The details of the primary dissemination study based on education level from elementary to university level are presented in Figure 3.

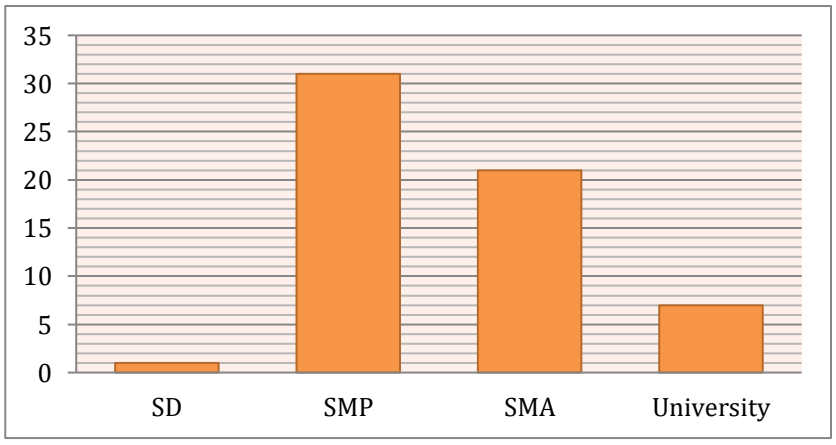


Figure 3. The study by Education Level

Based on figure 3, the study was mostly done at the middle school (SMP), with as many as 31 studies. The next was mostly done at the senior high school (SMA), with 21 studies, and at the university level, with seven studies. Meanwhile, there was less research on mathematical critical thinking ability at the elementary level with 1 article. It is in line with the findings of research by Dadang Juandi (Juandi, 2021) that junior high school students primarily practice all mathematical abilities, particularly problem-solving skills.

Study Based on Grade Level

There was 13 grades level, including 5th-grade elementary school students, 6thgrade elementary school students, 7th-grade junior high school students, 8th-grade junior high school students, 9th-grade junior high school students, 10th-grade senior high school students, 11th-grade senior high school students, 12th-grade senior high school students, 1st-semester college students, 3rd-semester college students, 4th-semester college students, 5th-semester college students, and 6th-semester college students. The details of the primary dissemination study based on grade level are presented in Figure 4.

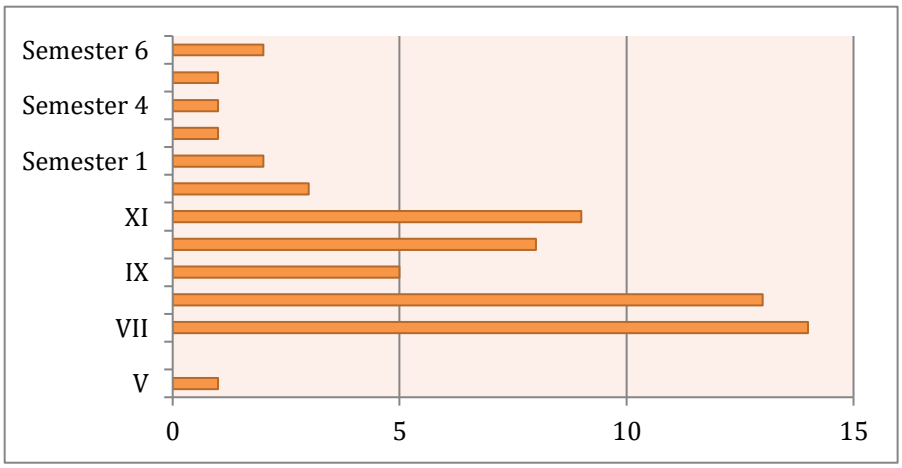


Figure 4. The study is based on Grade Level

Figure 4 shows that critical thinking skills are studied the most in 7th-grade junior high school students, with as many as 14 studies. The next highest is in 8th-grade junior high school students with as many as 13 articles, and the least is done at the elementary school level, namely in grade 5 elementary school as much as 1 study.

Study Based on Journal Indexing

The following details of the results of the primary study analysis related to the analysis of mathematical critical thinking skills using a qualitative approach based on the journal indexer are presented in Figure 5.

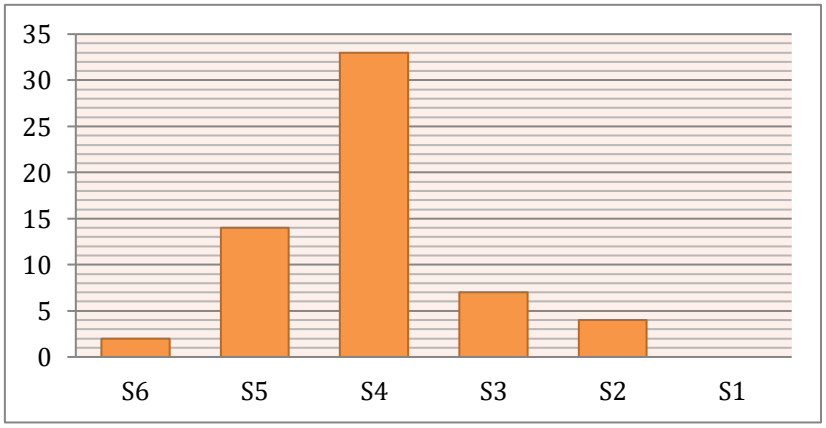


Figure 5. The study based on published in Journal Indexed by Sinta

From the picture above, it can be concluded that the results of studies related to mathematical critical thinking skills with a qualitative approach are widely published in journals indexed by Sinta 4, namely as many as 33 studies. Meanwhile, the indexed journals for S6, S2, and S1 are still few.

Study Based on Teaching Materials Used In Research

The details of the primary dissemination study based on education level from elementary to university level are presented in Figure 6.

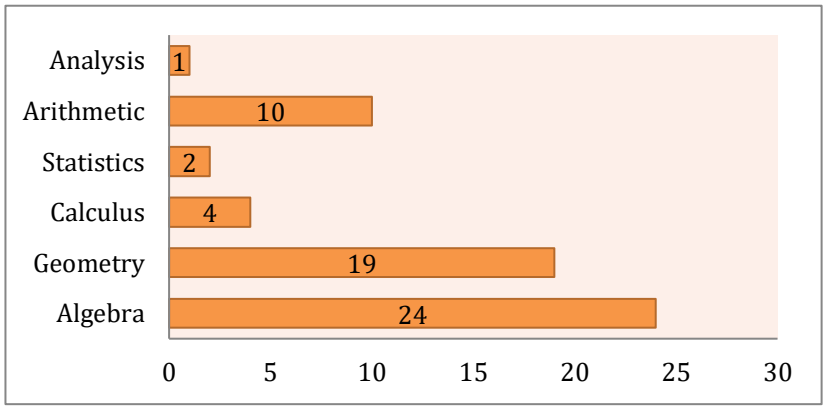


Figure 6. The study is based on Teaching Materials used in Research

Figure 6 shows that the branch of mathematics most widely used in research related to the analysis of mathematical critical thinking skills is algebra, with as many as 24 articles. The next highest is geometry, with as many as 19 studies, and the teaching material that is still little used in research is analysis.

Study Based on Research Location

Details of the distribution of studies based on demographics related to the analysis of mathematical reasoning abilities with a qualitative approach from regions in Indonesia are presented in Figure 7.

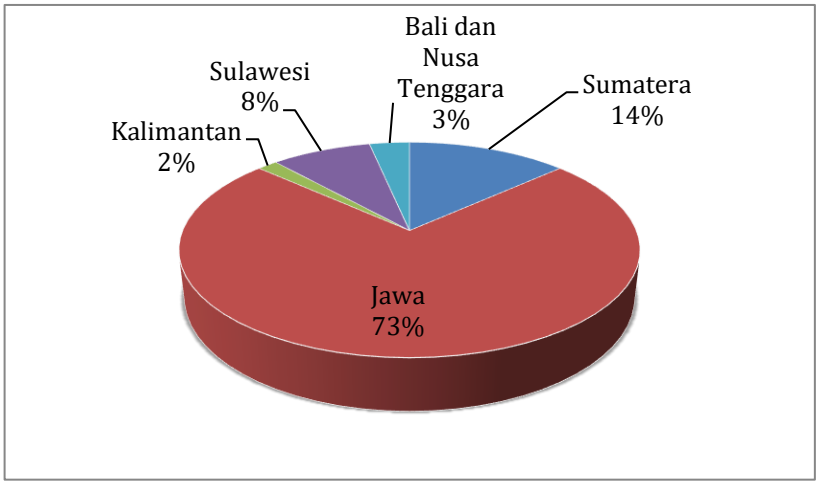


Figure 7. The study is based on Demographics

Figure 7 indicates that 44 studies, or 73% of the total, are concentrated on the island of Java and deal with the qualitative analysis of mathematical critical thinking skills.

However, it still leaves room for improvement in other areas. There are only 2% in Kalimantan or one study, and only 3% in Bali and Nusa Tenggara, or two studies.

Study Based on the Indicator of Critical Thinking Ability

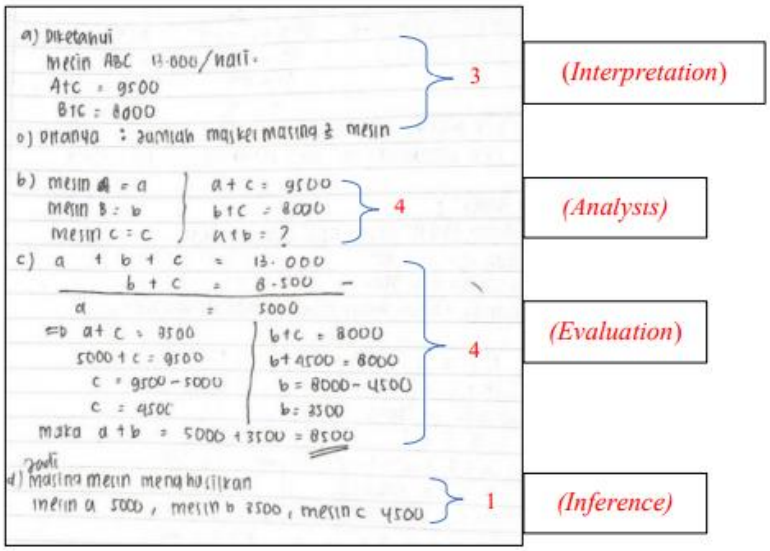
Based on the analysis of 60 articles related to critical thinking skills with a qualitative approach, it found many conditions when students cannot answer the question correctly, providing arguments or reasons in answering and drawing conclusions appropriately according to the context of the problem. The analysis result is presented in Table 2 below

Table 2. The results of the analysis of the articles

No	Researcher	Year	Result
1	L. Rifqiyana , Masrukan, B. E. Susilo	2016	Field-dependent and field-independent students have difficulties in concluding according to facts.
2	W Pertiwi	2018	the aspect of students' critical thinking skills, namely inference, as many as seven students can make conclusions correctly. In addition, as many as 29 students could not conclude correctly. It indicates that the ability of students to analyze is still low because only 19.44% of students can conclude correctly.
3	R Purwati, H Hobri, A Fatahillah	2016	Interpretation indicators are in the high category. Analysis indicators and evaluation indicators are in the medium category. For inference, indicators are in a low category.
4	FN Rani, E Napitupulu, H Siregar	2018	Students more dominantly mastered interpretation indicators in completing critical thinking skills tests that the teacher with 80.58% had given. In contrast, in the analysis indicators of 32 students, it was found that 61.94% of students were able to master these indicators, for evaluation indicators 57.36% and inference indicators with a percentage of 56.96%.
5	Reni Astari Hidayat , Sri Hastuti Noer	2021	Students who are at a high level of self-efficacy know that for each indicator are mastered on indicator 1 (giving simple descriptions), as many as three students or 100%, for indicator 2 (providing strategies and tactics), as many as three students or 100%, for indicators 3 (making further explanation) as many as three students or 100%, and for indicator 4 (making conclusions) as much as 66.67%. Then, 15 students who are in self-efficacy are known in each indicator of the ability to think critically mathematically for indicator 1 (providing simple descriptions), as many as ten students or 66.67%, for indicator 2 (providing strategies and tactics), as many as 12 students or 80%, for indicator 3 (making further explanation) as many as eight students or 53.33%, and for indicator 4 (making conclusions) as many as five students or 33.33%. Furthermore, seven students in the category of high self-efficacy levels obtained that from each indicator of mathematical critical thinking ability for indicator 1 (providing simple explanations) as many as four students or 57.14%, for indicator 2 (providing strategies and tactics) as many as three students or 42.86%, for indicator 3 (making further explanation) as many as one student or 14.29%, and for indicator 4 (making conclusions) as many as 0 students or 0%.
6	Ummi Athifah, Hikmatul Khusna	2022	Female students with moderate Self-confidence (SP) were able to complete SPLTV questions by fulfilling three indicators of critical thinking skills well. The shortcomings found in the inference indicator, namely by concluding, are caused by a lack of accuracy in reading the question instructions. Male students with moderate Self-confidence (SP) could solve SPLTV questions by only fulfilling two indicators well. The same thing completes the inference indicator, which draws equally imprecise conclusions. From these two

			questions, the inference indicators of female and male students tend to be less able to conclude answers correctly.
7	Vanie Dewi Rosliani, Dadang Rahman Munandar	2022	Based on indicators of students' critical thinking skills, 100% of students can interpret questions, 50% of students can analyze questions, and 15% of students can evaluate and make inferences or draw conclusions according to what is asked
9	Nurhalimah , Rahmi , Mulia Suryani	2021	Most mistakes made by students involve making simple explanations, strategies & tactics, and conclusions.
10	I Danike, EAR Arhasy, SR Muslim	2019	Students are not able to use the right strategy in solving problems as well as complete and precise in making calculations, and students are also unable to make conclusions correctly
11	A Dassa, N Nursakiah	2021	When formulating the problem to the mathematical model, the subject cannot formulate a description of the symbols from the predetermined mathematical model. At the stage of deducing, the subject is unable to provide conclusions.
12	M Roudlo, D Dwijanto	2022	Most of the students were not used to or unable to write down the main points of the problems and in providing conclusions based on valid logic
13	Siti Zulaeha Dwi Lestari, Lessa Roesdiana	2021	Based on the results of the analysis carried out by the researcher from several student answers, it turns out that there are still many students who are still unable to interpret data. Students are not proficient in analyzing questions correctly and precisely and are not proficient in making inferences.

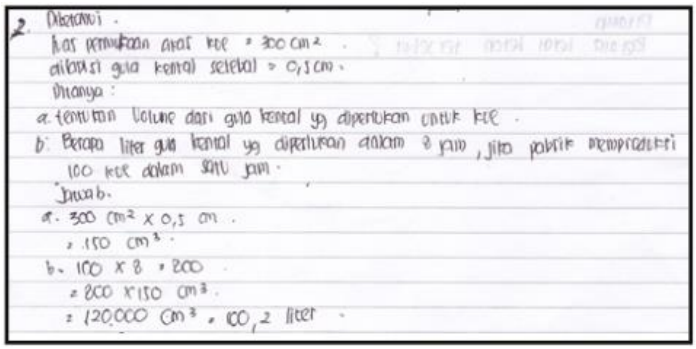
The following is an example of students being unable to provide conclusions appropriately.



(Source: Ummi Athifah, 2022)

Figure 8. Inappropriate conclusion

Based on figure 8, we can conclude that students cannot conclude appropriately according to the context of the problem. In this case, the students wrote, "So each machine produces machine a 5000, machine b 3500, and machine c 4500". In the meantime, the issue is how many masks each machine produces. Students can write conclusions even though the conclusions given are incorrect. The following is another example of student errors in the inference stage.



(Source: L.Rifqiyana, 2016)

Figure 9. Student's answer without any conclusion

Figure 9 shows the student's answer to a geometry problem. We can see that the student just wrote solutions without a conclusion. The student is not being able to conclude the problem. Therefore, it is highly expected that educators innovate in developing and implementing learning models that can facilitate students' mathematical critical thinking skills, especially in providing arguments or reasons in answering and drawing conclusions appropriately according to the context of the problem. It is further strengthened by thinking about the importance of mathematical literacy skills, one of the core competencies, namely reasoning abilities closely related to the ability to draw conclusions and provide arguments.

CONCLUSION

Research on the analysis of mathematical critical thinking skills with a qualitative approach has increased over the last ten years and will be most widely published in 2021 and 2022. This study is carried out the most in Java, while for areas outside Java, there are still few, especially Kalimantan, Bali, and Nusa Tenggara. Most studies were conducted at the junior high school level with research subjects grade 7 in the branch of mathematics Algebra and are published the most in indexed journals Sinta 4. Information on research developments related to the analysis of critical thinking skills in Indonesia can be a reference for researchers in the future. It is highly recommended for educators and researchers to further research critical thinking skills in areas outside Java, at the elementary education level, and in materials other than algebra. In addition, it is suggested that educators and researchers be able to innovate by developing learning models to improve mathematical critical thinking skills, especially in inference.

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