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Research Article

Trend of critical thinking skill studies in mathematics education: A study design to data analysis

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ABSTRACT

The aim of this study was focuses on the analysis of international publications related to critical thinking skills in education including the number of publications and how they trend, the distribution of study countries, study types, study subjects, critical thinking linkages that arise from published publications. analyzed, data collection instruments, data analysis and results of study on these publications. the most distribution of data related to critical thinking skills in 2021 with the distribution of countries namely Indonesia, USA, Iran, Malaysia, Turkey, UAE and the most publications obtained by Indonesia. The most common type of study is qualitative study, followed by quantitative study and then study and development. The study subjects used in the article are quite spread out from early childhood, elementary school students, junior high school students, high school students, university students, teachers to the books used. Most of the study trends discussed here relate to teacher pedagogical competence, problem solving, achievement, creative thinking, peer shared intervention and communication skills as a form of cooperation in 21st century skills. Test instruments are used the most, then questionnaires, interviews, continued questionnaire and observation guide, systematic literature review and finally book scoring. data analysis using percentage is the most, data analysis with descriptions then t test and ANOVA.

Keywords: critical thinking; mathematics; education; systematic literature review;

1. INTRODUCTION

The Industrial Revolution 4.0 is currently referred as an era of disruption that cannot be separated from the existence of innovative products. Disruption in question is an innovation that is a threat to symptoms that have existed / incumbent (Kasali, 2018). The threat in question is unpreparedness for the changes that occur. In addition, the industrial revolution 4.0 is also said to be robot automation, which means that the production process no longer relies on humans but is replaced with robots/technology (Sasongko & Sahono, 2016). This also certainly has an impact on education in Indonesia, especially during the pandemic period, it was enough to change the learning system to online or blended learning, where the interaction and process of character, moral, and exemplary education is certainly not optimal. Moreover, the fact shows that tutoring and tutoring are very abundant in Indonesia, this implies that classroom learning has not fully provided what the government wants because students still need other guidance and interpreting the learning gained at school as a process of evaluating knowledge alone is not in itself. character, moral and exemplary education.

The results of the reflection on the learning process in the classroom are also quite interesting. If you look at the study from time to time related to students' mathematical abilities and various learning methods, they have been very developed. This can be seen from the systematic literature review study on the topic of mathematics education study in Indonesia which was published with the Scopus index in 2018 to 2022 reaching 1113 documents (Supriyadi, 2022). The highest topic of discussion is learning mathematics, followed by the topic of mathematics and learning outcomes as the 3 most frequently discussed topics. This implies that there has been a lot of study in mathematics education in Indonesia, which has even been published internationally and is reputable.

Indonesian people face global problems such as population development, limited resources and employment, climate change, culture and economic dynamics of society as well as a variety of information which certainly requires strong validation. This is stated in the 21st century skills that a person needs to have, namely the 4Cs, namely Critical Thinking or Critical Thinking, Collaboration or collaboration, Communication or Communication and Creativity or Creativity. The independent curriculum in Indonesia, which has been running for more than a year, mentions the ability to think critically as one of the profiles of Pancasila students. Of course, to prepare students who have the ability to think critically in this era, teachers as educators need to have this critical thinking ability first.

However, the fact is that the implementation of learning in Indonesia is still not fully focused on the various mathematical abilities of students or using various learning methods. The results of a learning survey carried out in 11 schools spread across Sukabumi City showed that only 37% carried out various learning methods and 94% focused on mathematical understanding skills only. This of course implies that in addition to the threat of the industrial revolution 4.0, educators also need to reflect on the objectives of the learning carried out, namely to prepare students who are ready to enter a society where they have noble character, independence, critical reasoning, global diversity, mutual cooperation and creativity.

Study related to critical thinking skills also needs to be studied how the position and contribution of knowledge so far to education in the world. It aims to examine the extent to which study related to critical thinking skills supports the realization of the 21st century skills previously described. So the author intends to analyze related international publications related to critical thinking skills in education including the number of publications and how they trend, the distribution of study countries, types of study, study subjects, critical thinking links that arise from the analyzed publications, data collection instruments, data analysis and results from study on these publications.

Systematic literature reviews that have existed include (Costa, 2020) who analyzed study trends of 2010-2019 concerning critical thinking in science education and mathematics educationthe purpose of the study is to identify the main characteristics of these articles in terms of authors, years of publications, periodicals, authors institutions, countries, citations, teaching levels, fields, the main references cited, and the number of mentions of the term critical thinking. Apart from that (Fahimah, 2021) also analyzes study trends of 2009-2018 about implementation of Problem Based Learning to Critical Thinking ability in school, to verifying the essential implementation of the PBL in sharpening the capability of the data on online study. From the several SLR studies, no one has discussed depthly how the results of each study are based on the type of study and analysis of indiactors of critical thinking skills used in the study. So that studiess aim to analyze study trends related to critical thinking skills and analysis of study results and analysis of indicator used.

2. RESEARCH METHOD

2.1 Study Design

This study is a systematic literature review that focuses on the analysis of international publications related to critical thinking skills in education including the number of publications and how they trend, the distribution of study countries, study types, study subjects, critical thinking linkages that arise from published publications. analyzed, data collection instruments, data analysis and results of study on these publications.

2.2 Data Source

The data comes from the results of study related to critical thinking skills in mathematics education published in the article. The article in question came from Google Scholar from 2018 to 2022 on mathematics education articles that discussed critical thinking skills were obtained with the help of the Publish or Perish 8 application.

2.3 Study Instrument

The questions that are the focus of this study are:

a. What are the study trends related to critical thinking skills from 2018-2022?
b. What are the types of study related to critical thinking skills from 2018-2022?
c. How are the study subjects related to critical thinking skills from 2018-2022?
d. How is critical thinking skills study related from 2018-2022?
e. How are the instruments used related to critical thinking skills from 2018-2022?
f. How is the data analysis used related to critical thinking skills from 2018-2022?
g. How is the results analysis of each type of study related to critical thinking skills from 2018-2022?
h. How is the indicators used in each study related to critical thinking skills from 2018-2022?

To answer those questions, so the instrument used in this study consisted of 8 items, namely 1) the number of publications each year; 2) the type of study; 3) study subjects; 4) the trend of study linkages; 5) the data collection instrument used; 6) analysis of the data used and 7) Result analysis of each type of study; 8) analysis of indicators used from each study. Items number 1), 4) , 7) and 8) were not formulated for the category of analysis results before the study, but were recorded after the analysis of each article. While items number 2), 3), 5), and 6) the tendency of the answers are categorized into several answers and formulated before the study, the details are as follows:

Table 1. Instruments

Aspects	Categories
Type of quantitative study (2a)	A1. Correlations A2. Quasi Eksperiments
Type of qualitative study (2b)	B1. Case Study B2. Phenomenology B3. Descriptive Qualitative
Type of study and development (2c)	C1. Product C2. Process
Study subject (3)	D1. Early childhood D2. Elementary students

	D3. Junior high school students D4. Senior high school students D5. Undergraduate students D6. Teachers D7. Book
Instruments (5)	E1. Test E2. Questionnare E3. Observation journals E4. Interview journals E5. Book Scoring E6. Guideline Content Analysis
Data Analysis (6)	F1. ANOVA F2. t test F3. Descriptions F4. Percentage

2.4 Data Analysis

The stages of data analysis in this study are as follows:

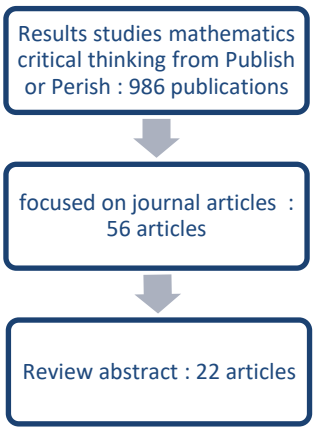

Figure 1. The stages of data analysis

By using Publish or Perish 8 application, 986 publications were obtained that discussed the focus on critical thinking skills in education. Then from 986 publications, they were selected to focus on journal articles in Mathematics Education, so that 56 articles were obtained. Then the abstracts of the 56 articles were reviewed so that only 22 articles were eligible for analysis in this study. Each article is analyzed based on the previously described instrument. Then the results are presented in various diagrams including line charts, pie charts and bar charts. In addition, the findings from the analysis are also deepened in order to see study that might be used as material for further study.

3. RESULTS AND DISCUSSION

3.1 Number of Publications

The articles analyzed consisted of 22 articles on Google Scholar internationally discussing critical thinking skills on the subject specified in their respective areas. The publication trend is shown in **Figure 2.**

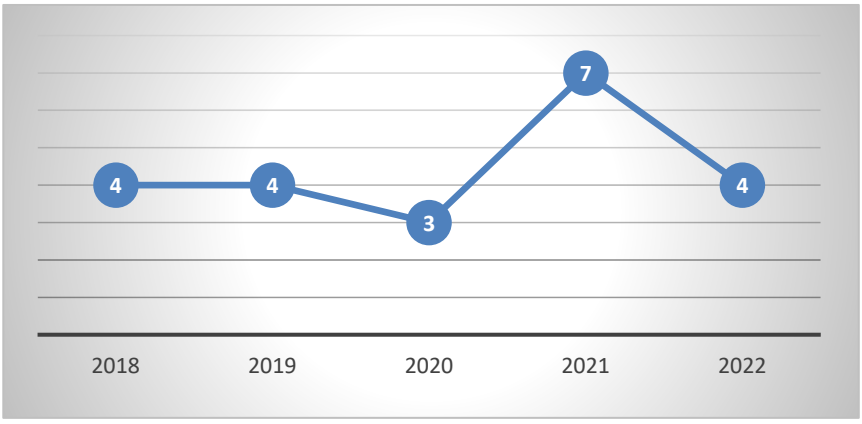

Figure 2. Publication Trend

Based on the **Figure 2**, it can be seen that publications from 2018 to 2019 were quite stagnant and experienced a decline in publications by 25% in 2020. Then in 2021 study related to critical thinking skills rose quite significantly. reaching more than 100% from 2020. And in 2022, currently Google Scholar publications related to critical reasoning skills have only reached 4 and in 2022 it is possible that there will still be additional international publications indexed by GoogleScholar. The decline in publications in 2019 to 2020 because more than 70% of study is also diverted to the topic of distance learning and the right method for delivering learning during the pandemic era (Nugraha, 2020). This is because at that time the world of education became one of the victims of the pandemic that occurred, so that it was no longer the content or perhaps the characteristics of students (such as students' mathematical abilities) that became the main focus but rather solutions to deliver learning optimally, even though the intent was optimal. here is mathematics as the subject not the conceptual tool (Harel, 2011). Then in 2020 to 2021, study related to students' mathematical abilities will increase again because it becomes the main topic that is highlighted as a post-pandemic effect, including one of them is critical thinking skills.

The distribution of the area of origin of the studies is as follows:

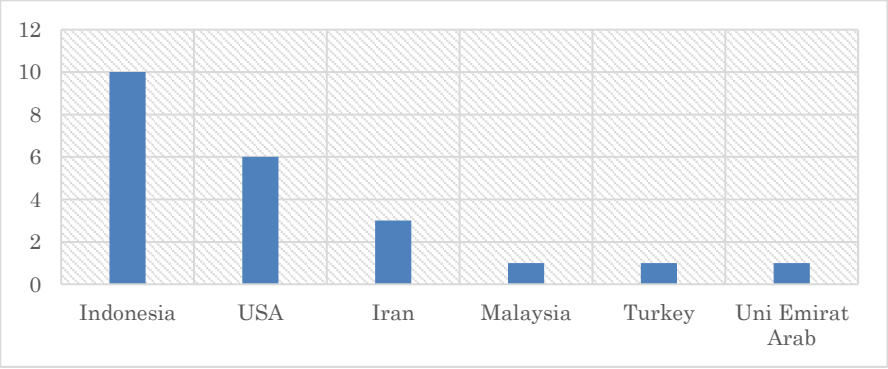

Figure 3. The Area Of Origin Of The Studies

Based on **Figure 3**, it can be seen that Indonesia is quite different from the USA and other countries regarding the number of international publications indexed by googlescholar. So that Indonesia can be said to have been very good at highlighting education, including highlighting critical thinking skills that are very much needed in this 21st century.

3.2 Type of Study

The type of study analyzed from publications is shown in the following figure:

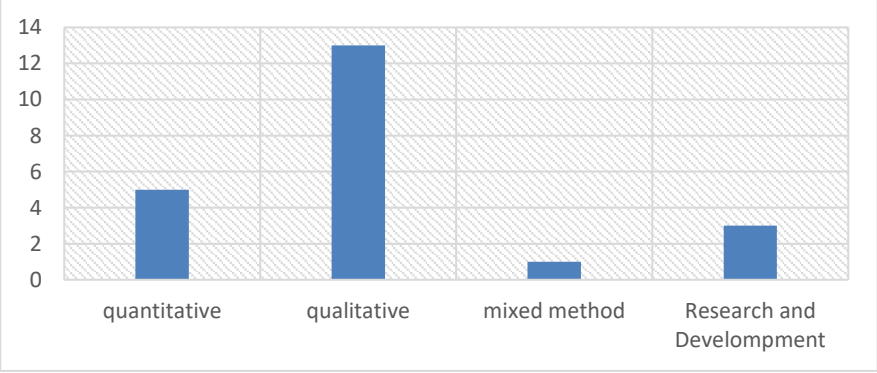

Figure 4. Type of Study

Figure 4, shows that the type of qualitative study is mostly compared to the type of quantitative study and other types of study. This is of course because to analyze the critical thinking ability of the subject in depth is based on the stages of constructing mathematical knowledge which are psychologically highlighted in the subject's cognitive development. In order to better understand the extent of the study scope of each article, the author tries to describe quantitative, qualitative and Study and Development study into more specific sub-studies, which is shown in **Figure 5.**

Figure 5, shows the direction of the study The quantitative study used in the articles analyzed is 40% is correlation study and 60% is quasi-experimental study. In correlational study, the studies investigates the relationship between critical thinking skills and other variables, including achievement motivation and attitude towards mathematics, followed by path analysis and then partly examines the relationship with cognitive flexibility and achievement. This is clear because of the position of critical thinking skills which can be seen as a process of constructing knowledge so that it is possible to relate other mathematical thinking skills or cognitively or affectively. Meanwhile, quasi-experimental study carried out certain treatments to see whether or not there was a significant difference between the experimental class and the control class. The treatments carried out included comparisons of the STEM experimental class for efficiency and effectiveness with the

ordinary STEM control class, the problem solving based methods experimental class with the ordinary control class, the personalized learning experimental class and the ordinary control class. As for qualitative study, it can be seen in Figure 6.

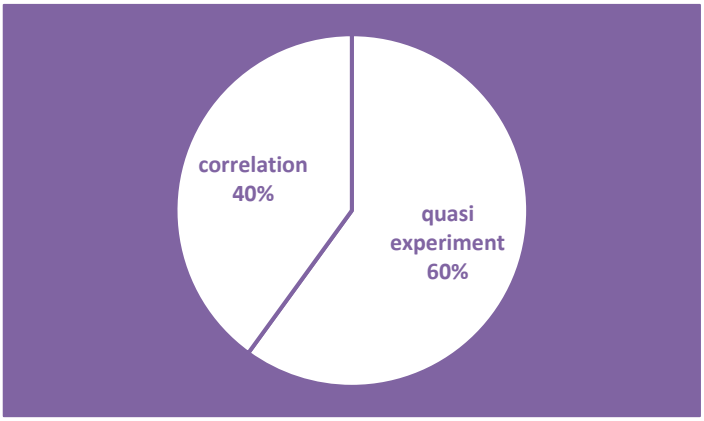

Figure 5. Type of Quantitative Study from Articles

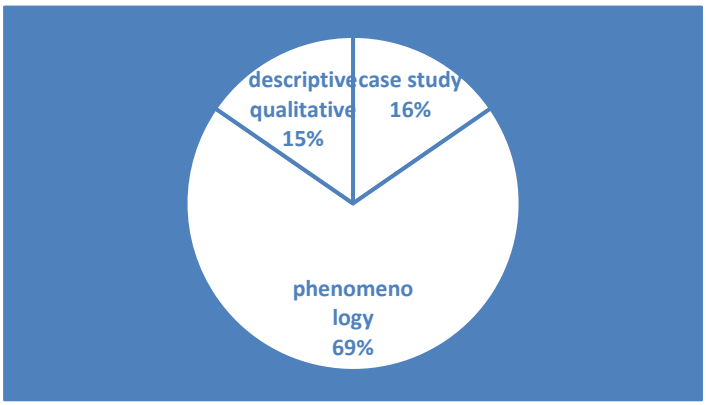

Figure 6. Type of Qualitative Study from Articles

Based on the **Figure 6**, it can be seen that the direction of qualitative study in the articles analyzed is 69% is phenomenological study, 16% is case studies and 15 % is descriptive qualitative. Phenomenological study emphasizes more on the essence of one's experience of exploring an individual's life (Creswell, 2015). Meanwhile, case study study is an approach that focuses on experiential knowledge about cases and careful attention to the influence of social context and activities according to Robert E. Stake (Denzin, 2009). The descriptive qualitative study is in this case to build a theory where the theory is compiled based on the results of existing field data (Creswell, 2015). As for study and development, the results are as follows:

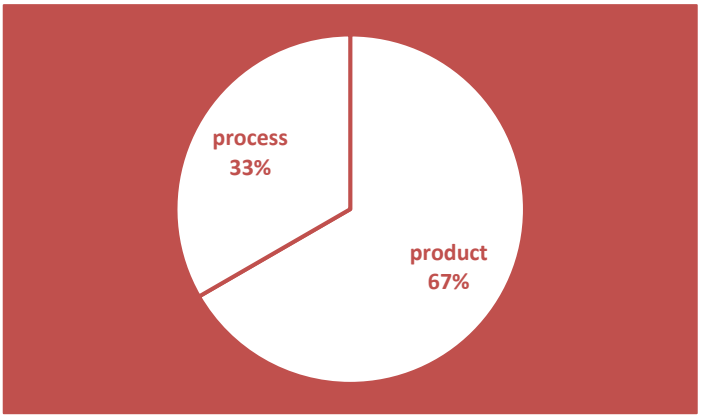

Figure 7. Output from Study and Development

Based on the picture above, it can be seen that study and development produces 67% product and produces 33% process. In study and development that produces products, including producing games as learning media which also includes teaching materials in it, such as modules and android games. Meanwhile, study and development produces a process, namely the math set game in which there is a game process that simultaneously presents the process of learning mathematics.

3.3 Study Subjects

The study subjects analyzed in the articles are summarized in the **Figure 8.**

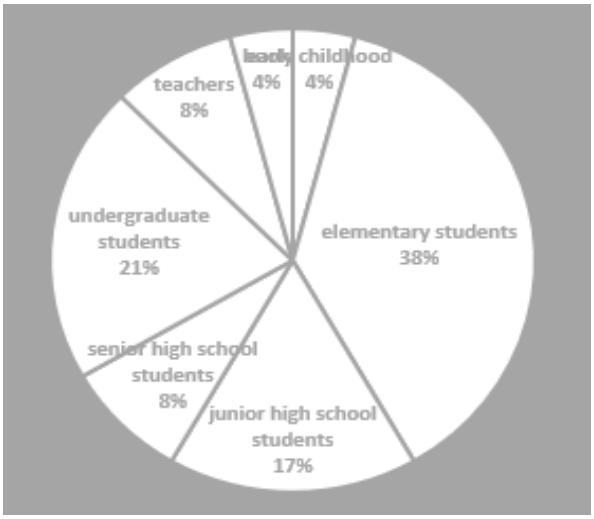

Figure 8. Study Subjects from Articles

Based on the **Figure 8**, it can be seen that 38% of the study subjects from the articles analyzed came from elementary school students and this is the subject most followed by students as much as 21%, then junior high school students as much as 17%, high school students 8% and teachers also 8% then early childhood 4% and books 4%. The thing that is in the spotlight is the subject which is a teacher and books have started to become a fairly common subject to be analyzed in study. This shows that the direction of study has begun to cover not only the direction of students, but the pedagogical abilities of teachers and books as teaching materials have also begun to be analyzed and investigated further for the sake of achieving better education. In didactical design study that is currently developing to detect learning obstacles from students, it can also be seen from the pedagogical competence of teachers and also the teaching materials used, for example with praxeology (Chevallard, 1989). This of course explains the role of mathematics in learning not only as a subject, but also as a conceptual tool for constructing mathematical knowledge in students (Harel, 2011).

3.4 Study Links

The analyzed articles also point to several emerging trends, which can be seen in the **Figure 9.**

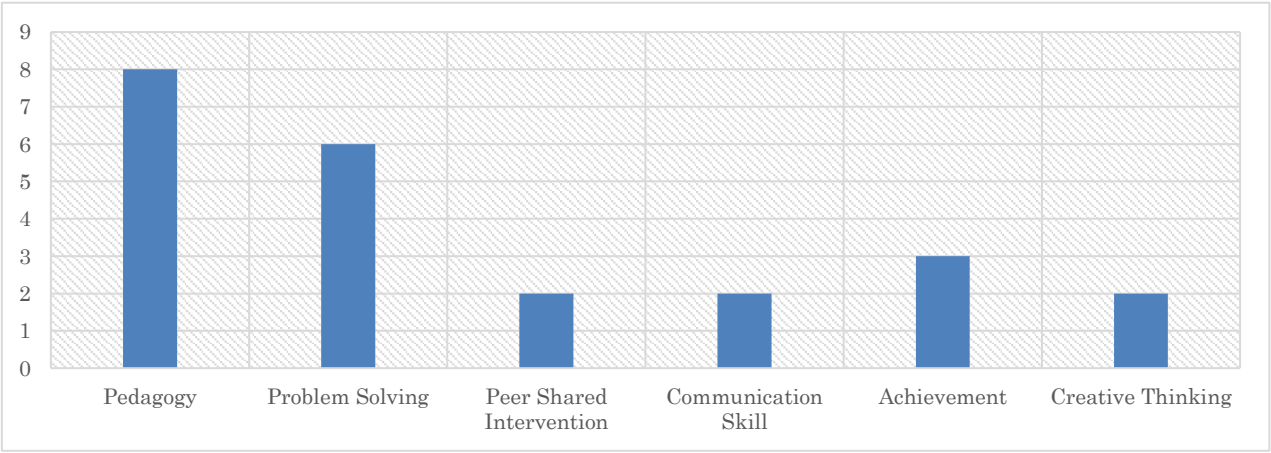

Figure 9. Study Links from Articles

Most of the study trends discussed here relate to the pedagogical competencies of teachers that are expected to be present in learning that encourages critical thinking skills. This is in accordance with the role of the teacher who is expected to be present not only to teach mathematical concepts or how to count, but also a way of viewing learning as a didactic atmosphere that encourages the creation of mental acts from students and then colors students' ways of thinking so that it is expected to arrive at a better way of understanding. is a product of learning (Suryadi, 2019). In addition, the next highest trend is related to problem solving in learning and working on questions, this is in accordance with the meaning of 21st century skills mentioned earlier. In addition, critical thinking skills that arrive at ways of understanding will be able to stimulate problem-solving skills for students. The next trend is achievement, creative thinking, peer shared intervention and communication skills as a form of cooperation in 21st century skills.

3.5 Data Collection Instruments

The instruments used in the articles discussed are shown in **Figure 10.**

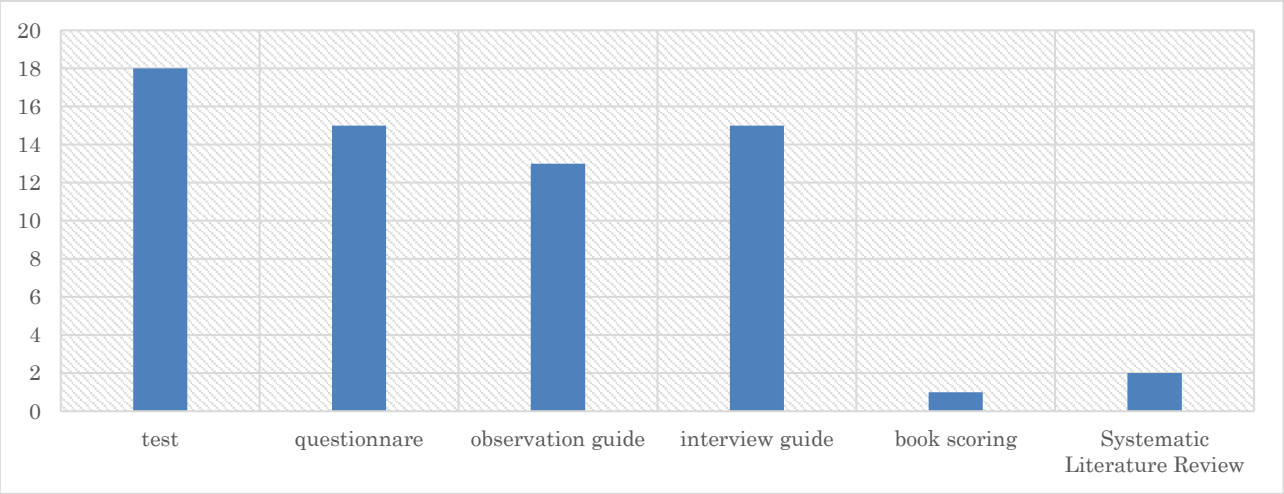

Figure 10. Data Collection Instruments from Articles

Based on **Figure 10**, it can be seen that the test instrument is used the most, then questionnaires, interviews, followed by questionnaires and observation guides, systematic literature reviews and finally book scoring. The test instrument used is very clear to measure the critical thinking ability of human subjects described in the previous discussion, and of course this test is based on the stages of critical thinking skills used by several experts. Among them, based on (Ennis, 2015) mentions that there are 6 stages, namely focus, reasons, inference, situations, clarity and overview. Meanwhile, based on the Theory of the Characters (Facione, 2011) there are 5 stages, namely analytical interpretation, inference, evaluation, explanation, and self-control. Meanwhile, according to Purkins & Murphy (Kennedy, 2004) there are 4 stages, namely, assessment, conclusion, and strategy/tactics. As for (Watson, G. & Glaser, 2008) there are 4 stages, namely drawing conclusions, assumptions, deductions and interpreting information. Questionnaires used in general to measure the critical thinking stage of students based on questions with a Likert scale to ensure the results of the tests used. If the case is study and development, then this questionnaire is generally used to see user responses to the resulting product/process. Observation guides are also used to validate the results obtained from other instruments, as one of the considerations to seek the truth of knowledge approaching the truth, for example by the triangulation process.

3.6 Data Analysis Method

The data analysis method used in the article in this study is shown in **Figure 11.**

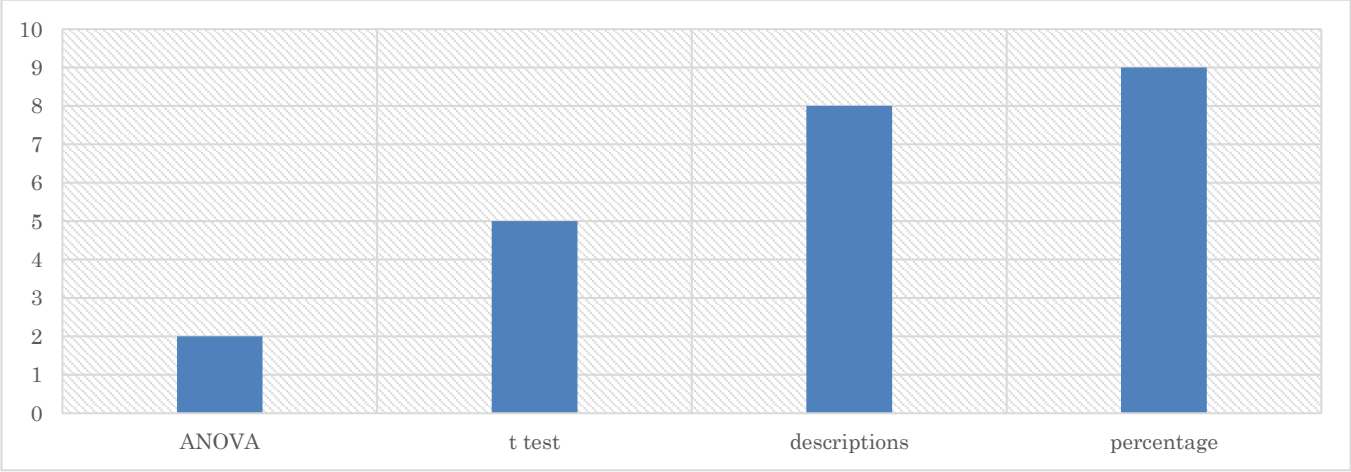

Figure 11. Data Analysis Methods from Articles

Based on the **Figure 11**, it appears that data analysis using percentages is the most common, for example used to measure the achievement of each indicator of critical thinking ability or perhaps the effectiveness of the application of treatment in experiments, shows how big the relationship is in correlational study and the effectiveness of the products/processes produced in study and development. Next, data analysis with descriptions is used to explain the study results which are usually in the form of qualitative descriptive study and complete the percentage in the previous data analysis. T test and ANOVA were used to analyze the data from the comparison of the experimental class and the control class if it was an experimental study, the effectiveness of the product or process if it was study and development.

3.7 The results analysis of each type of study

The results analysis of each type of study:

Type of Study		The Result Analysis
Quantitative	Correlations	Critical thinking ability has a significant effect on problem solving ability and cognitive flexibility and achievement.
	Quasi Experimental	Critical thinking-based learning methods associated with problem solving, personalized learning, communication, creative thinking and STEM are significantly different from the control class. The control class used is a class with a learning method that is not based on critical thinking.
Qualitative	Descriptive Qualitative	The results were determining ways to improve critical thinking skill in math dan prospective teacher's expectation of students' critical thinking process in solving mathematical problems based on Facione stages.
	Case Study	the result were using peer-shared intervention strategies for promoting math explorations and critical thinking in early childhood inclusive classrooms, serta kasus lain yakni math related critical thinking theory in civil engineering design.
	Phenomenology	The result is an in-depth study of teacher perceptions of professional learning communities-impact on math critical thinking pedagogy, using natural language processing coding to explore math learning and critical thinking, using peer assisted reflection in math to foster critical thinking and communication skills, math oriented critical thinking skills and how to present learning that sharpens critical thinking skills.
Mixed Method		Comprehensive analysis of various aspects including the curriculum to see the sharpness of students' critical thinking skills includes analysis of the books used, analysis of students' critical thinking skills and analysis of teachers' critical thinking skills and the learning presented.
Research And Development		The resulting products include learning applications, learning modules and games in learning that sharpen students' critical thinking skills.

3.8 The indicators of Critical thinking used in each study

The indicators used from the research analyzed focus on 9 theories including local curriculum guidelines, local psychological associations, Facione, Johnson and Ennis. The description of the distribution of indicators used in each study is as follows:

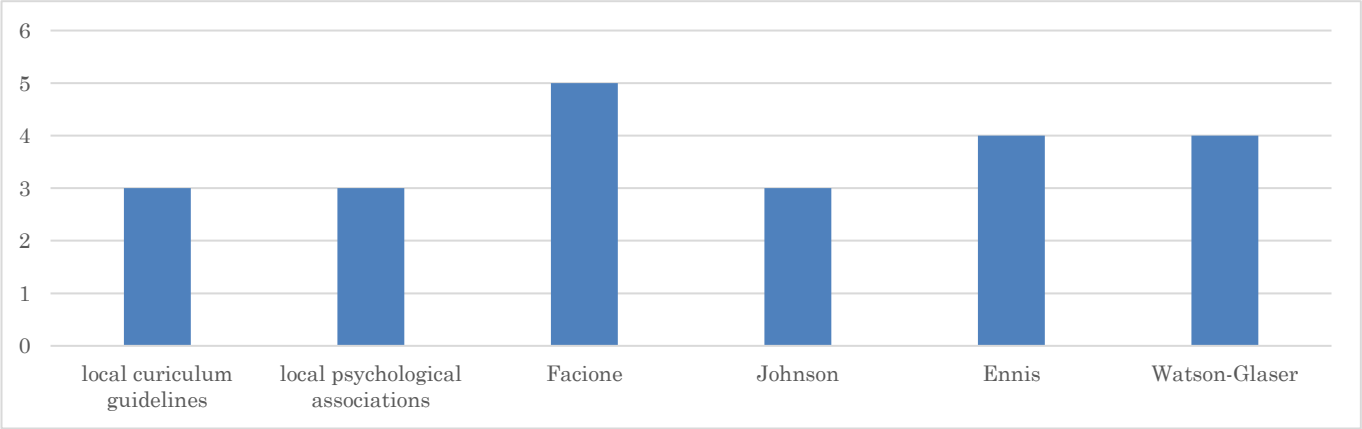

Figure 12. the indicators of Critical Thinking Used in Each Study

Based on the **Figure 12**, it can be seen that the most widely used indicator is based on the theory of Facione, Watson-Glaser and Ennis. Facione mentions that indicators of critical thinking skills include interpretation, analysis, evaluation, explanation, inference and self-regulation (Facione, 2011). Meanwhile Ennis states that indicators of critical thinking are focusing questions, analyzing arguments, asking and answering clarification questions, considering whether a source can be trusted or not, observing and considering the results of observations, making deductions and considering the results of deductions, making inductions and considering the results of induction, making and considering decision values, defining terms and considering definitions, identifying assumptions, determining actions and interacting with others (Ennis, 2015). However As for (Watson, G. & Glaser, 2008) there are 4 stages, namely drawing conclusions, assumptions, deductions and interpreting information.

4. CONCLUSION

The publication of articles on Google Scholar from 2018 to 2022 found 22 articles with the most distribution of data related to critical thinking skills in 2021 with the distribution of countries namely Indonesia, USA, Iran, Malaysia, Turkey, UAE and the most publications obtained by Indonesia. The most common type of study is qualitative study, followed by quantitative study and then study and development. The study subjects used in the article are quite spread out from early childhood, elementary school students, junior high school students, high school students, university students, teachers to the books used. Most of the study trends discussed here relate to teacher pedagogical competence, problem solving,

achievement, creative thinking, peer shared intervention and communication skills as a form of cooperation in 21st century skills. Test instruments are used the most, then questionnaires, interviews, continued questionnaire and observation guide, systematic literature review and finally book scoring. data analysis using percentage is the most, data analysis with descriptions then t test and ANOVA. The results analysis shows that various awesome effect based on critical thinking in learning and that the most widely used indicator is based on the theory of Facione, Watson-Glaser and Ennis.

AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

REFERENCES

Chevallard, Y. (1989). On didatic transposition theory: some introductory notes. *Lnternational Symposium on Selected Domains of Research and Development in Mathematics Education*, 1–9. http://yves.chevallard.free.fr/spip/spip/article.php3?id_article=122

Costa, S. L. R. (2020). Critical thinking in Science education and Mathematics education: research trends of 2010-2019. *Research, Society and Development*, *9*(9).

Creswell. (2015). *Riset Perencanaan, dan evaluasi riset kualitatif dan kuantitatif Pendidikan*. Pustaka Pelajar.

Denzin, N. K. dan Y. S. L. (2009). *Handbook of Qualitative Research. Terj. Dariyatno dkk*. Pustaka Pelajar.

Ennis, R. H. (2015). Critical thinking: A streamlined conception. In The Palgrave handbook of critical thinking in higher education. *Springer*.

Facione, P. A. (2011). Critical thinking: What it is and why it counts. *Insight Assessment*.

Fahimah, H. M. (2021). Implementation of Problem-Based Learning to Critical Thinking Ability in School: A Systematic Literature Review. *Proceedings of the 1st International Seminar on Teacher Training and Education*, *1*.

Harel, G. (2011). *The framework presented here is part of the DNR Project, supported, in part, by the National Science Foundation (REC 0310128). Opinions expressed are those of the author and not necessarily those of the Foundation. 1. Rec 0310128*, 265–290.

Kasali, R. (2018). *Disruption (9th ed.)*. Gramedia.

Kennedy, G. L. et al. (2004). The toxicology of perfluorooctanoate. *Critical Reviews in Toxicology*.

Sasongko & Sahono. (2016). *Desain Inovasi Manajemen Sekolah (1st ed)*.

Supriyadi, E. (2022). Bibliometrix Analysis of Learning Mathematics Studies From Indonesian Authors. *Jurnal Kajian Pembelajaran Matematika*.

Suryadi, D. (2019). *Landasan Filosofis Penelitian Desain Didaktis (DDR)*.

Watson, G. & Glaser, E. M. (2008). Watson Glaser Critical Thinking Appraisal. *Pearson Education, Inc*.