Trends of Physics Critical Thinking Skill Research in Indonesia: A Systematic Literature Review

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Abstract

Critical thinking skills are fundamental in 21st-century teaching. This study aims to identify trends in research on critical thinking skills in physics in Indonesia, as reported in journal articles published between 2016 and 2022. This is meta-analysis research using the Prisma model. There were 36 articles that met the selection criteria. We performed the data analysis manually and used VOSviewer software. The indicators used for data analysis include the year, type of research, research subject, topic, treatment, data collection instrument, and the application of data analysis in each article. The analysis of article reviews reveals that the research trend for critical thinking skills in physics in Indonesia has increased, with more publications expected in 2020. Temperature and heat are the physics topics that have become the focus of research. High school students in grade X are the most frequently selected research subjects. Research on physics education typically employs quantitative methods, employs a quasi-experimental design, and utilizes a test as a data collection instrument. The most common method of data analysis in research is the t-test.

Keywords: critical thinking skills, physics, systematic literature review

INTRODUCTION

The 21st century is a new era in which scientific and technological advances have developed rapidly. Currently, the teaching process not only imparts concepts but also equips students with the necessary skills. The skills needed to face the 21st century include critical thinking skills, skills in utilizing information and communication technology (ICT), and skills for solving problems (Adilla & Jatmiko, 2021). Along with the development of the revolutionary era, the competition for the quality of human resources (HR) is getting tighter. The nation's education level determines the quality of its human resources. Therefore, it is necessary to improve the quality of education according to Law No. 20 of 2003, education is an attempt by students to build learning conditions and an active learning process so that they can develop their potential.

In fact, the Organization for Economic Co-operation and Development (OECD) released the results of a survey by the Program for International Student Assessment (PISA) in 2018, which ranked Indonesia 74th out of 79 countries in the reading category, and 73rd and 71st in the reading category assessment of mathematics and science, compared to a 2015 survey, these results showed a decrease (Tohir, 2019). Trends in International Mathematics and Science Studies (TIMSS) also reported similar results. TIMSS 2015 ranks Indonesia 45th out of 48 countries globally, with a score of 397. This indicates that Indonesia is in the low science category, which can also mean low thinking skills. In

addition, the ability to answer questions using tables or graphs reaches only four percent of the total correct answers. Similar cases were also reported by several studies conducted in several locations in Indonesia, such as research conducted by (Nurazizah et al., 2017; Pamungkas et al., 2018) which states that students' critical thinking skills are still relatively low. Several factors, including the use of inappropriate teaching strategies and the lack of habituation to foster the development of critical thinking skills, can contribute to students' low critical thinking skills.

Educational development must be able to accommodate the optimization of empowering students' critical thinking skills (Strauss, 2016). Critical thinking skills refer to an individual's ability to analyze, interpret, evaluate, and construct arguments logically. According to Brookhart (2010), critical thinking is considered reflective thinking that focuses on deciding what to believe or do. In this case, "able to think" means that students can apply wise judgment or make reasoned criticism. Several indicators in determining critical thinking skills include (1) being able to understand and formulate the main issues; (2) being able to express reasons based on facts or evidence; (3) being able to make or select logical, relevant, and accurate arguments; (4) being able to explain the intent of the arguments made based on different points of view; and (5) being able to determine the consequences of an argument taken as a decision (Ika et al., 2020).

Based on previous research conducted by Juliyantika & Batubara (2022) with the research title "Critical Thinking Skills Research Trends in Basic Education Journals in Indonesia." This study uses a systematic review method to analyze the contents of articles published in Sinta-accredited Basic Education journals from 2017 to 2021, with a research focus on critical thinking skills. The instrument that analyzes the content of journal articles consists of six aspects. The six aspects include: (1) the year of publication; (2) the type of research; (3) the research subjects; (4) the data collection instruments; (5) the data analysis methods; and (6) the subjects. The difference between this research and the research conducted by the author is that the author adds trends in critical thinking skills at the junior high school, senior high school and undergraduate levels and the treatment is carried out to improve critical thinking skills. In addition, the author added the latest references referring to articles published from 2016 to 2022.

The Science and Technology Index (SINTA) has accredited several scientific journals of physics education and science between 2016 and 2022 for content analysis in this study. This study aims to collect information about various studies that examine critical thinking skills in Indonesia, especially in physics teaching. This study aims to address the following research questions in detail:

- Q1: What is the trend in the number of studies on critical thinking skills from 2016 to 2022?
- Q2: How diverse are the research designs used to investigate critical thinking skills in Indonesia?
- Q3: What topics are often used to investigate students' critical thinking skills?
- Q4: What treatments did the researcher apply to improve students' critical thinking skills?

METHODS

This research is a type of meta-analysis with a focus on critical thinking skills. The source of articles used are journals in physics education and science education that are registered in the Science and Technology Index (SINTA), consisting of SINTA 2, SINTA 3, and SINTA 4. SINTA (https://sinta.kemdikbud.go.id/journals) is a platform for measuring science and technology development designed and developed by the Indonesian Ministry of Research, Technology, and Higher Education. After being identified, 17 journals were found relevant to the topic to be studied. The articles analyzed in this study were published in 2016-2022 and were related to critical thinking skills. The 17 journals were used by the authors as sources in finding articles that are relevant to critical thinking skills. From the 17 reputable national journals, 117 articles were obtained with details as shown in FIGURE 1.

The systematic review model used is the PRISMA model with several criteria set by the author. The reviewed articles were selected with the following criteria. 1) Studies must be indexed by the SINTA database. 2) The articles discuss critical thinking skills in physics teaching. 3) Studies must be published as journal articles. 4) No proceedings. 5) Open access. The process of selecting the articles can be seen in FIGURE 2.
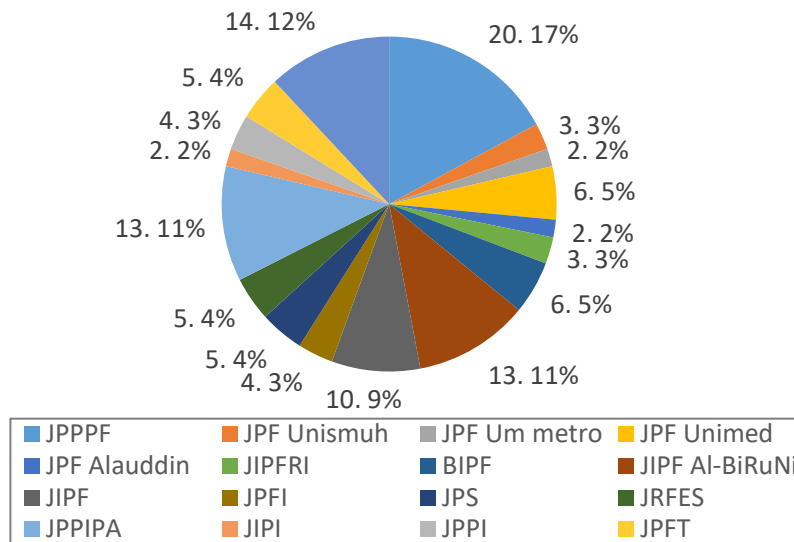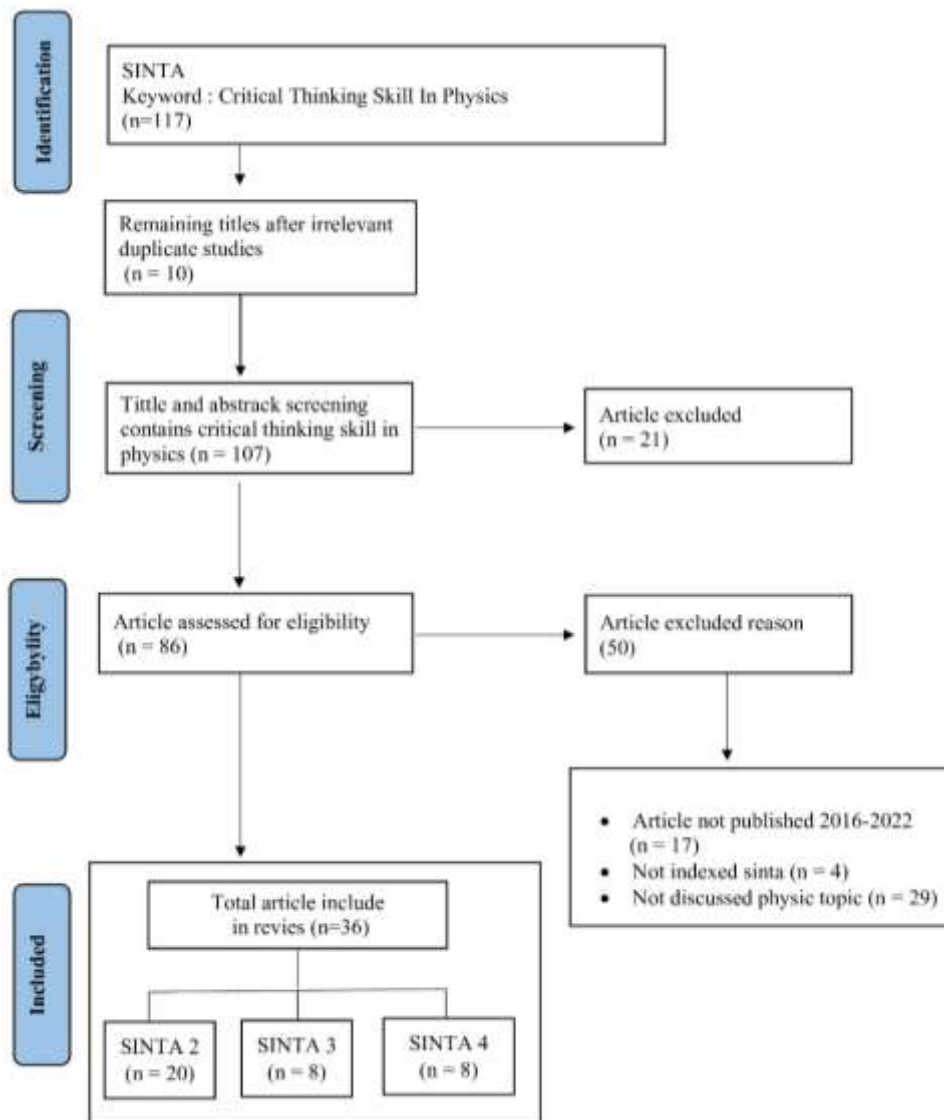
FIGURE 1. Distribution of article sources.

FIGURE 2. The article selection process.

Data from each of the articles reviewed were then analyzed, and several indicators analyzed were adjusted to certain aspects that met the indicators determined by the reviewer including year, type of research, subject, topic, treatment, data collection instrument, and data analysis. The relationship between title and abstract was analyzed using Vosviewer software while other indicators were analyzed manually. Furthermore, the data collected were presented in the form of tables and bar charts.

RESULTS AND DISCUSSION

The researcher's search yielded 117 articles that align with the critical thinking skills required for physics learning. However, after conducting the screening stage of articles that match the criteria determined by the researcher, 36 articles were obtained, those articles can be seen in TABLE 1.

TABLE 1. Articles That Match the Criteria Determined

No.	Authors	Journals
1.	Malik et al. (2018)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
2.	Malik et al. (2017)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
3.	Denny et al. (2020)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
4.	Nurazizah et al. (2017)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
5.	Melida et al. (2016)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
6.	Suci et al. (2022)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
7	Nafingah et al. (2020)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
8	Malik et al. (2019)	Jurnal Penelitian & Pengembangan Pendidikan Fisika
9	Pratiwi et al. (2019)	Berkala Ilmiah Pendidikan Fisika
10	Sari et al. (2022)	Berkala Ilmiah Pendidikan Fisika
11	Rohmatin et al. (2022)	Berkala Ilmiah Pendidikan Fisika
12	Darmaji et al. (2021)	Jurnal Ilmu Pendidikan Fisika
13	Liana & Nursuhud (2020)	Jurnal Ilmu Pendidikan Fisika
14	Samya et al. (2021)	Jurnal Ilmu Pendidikan Fisika
15	Sapitri et al. (2016)	Jurnal Ilmu Pendidikan Fisika
16	Nadiya et al. (2016)	Jurnal Ilmu Pendidikan Fisika
17	Agustini & Suyatna (2018)	Jurnal Ilmiah Pendidikan Fisika Al-Biruni
18	Negoro et al. (2020)	Jurnal Ilmiah Pendidikan Fisika Al-Biruni
19	Wartono et al. (2019)	Jurnal Ilmiah Pendidikan Fisika Al-Biruni
20	Khaeruddin & Bancong (2022)	Jurnal Ilmiah Pendidikan Fisika Al-Biruni
21	Susetyo & Ishafit (2022)	Jurnal Riset Fisika Edukasi Dan Sains
22	Sari et al. (2020)	Jurnal Riset Fisika Edukasi Dan Sains
23	Ika et al. (2020)	Jurnal Riset Dan Kajian Pendidikan Fisika
24	Nisa et al. (2018)	Jurnal Pendidikan Fisika Indonesia
25	Susilawati et al. (2020)	Jurnal Pendidikan Fisika Dan Teknologi
26	Rosdianto et al. (2018)	JIPFRI (Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah)
27	Raja et al. (2021)	Jurnal Pendidikan Fisika (JPF) Alauddin Makassar
28	Pratiwi et al. (2020)	Jurnal Pendidikan Fisika (JPF) UM Metro.
29	Dhina & Mubaroq (2017)	Jurnal Pendidikan Fisika (JPF) UNISMUH
30	Suparmin (2019)	Jurnal Pendidikan Fisika (JPF) UNISMUH
31	Sagala et al. (2019)	Jurnal Pendidikan Fisika (JPF) UNIMED
32	Nufus et al. (2018)	Jurnal Pendidikan Fisika (JPF) UNIMED
33	Wasyilah et al. (2021)	Jurnal Penelitian Pendidikan IPA (JPPIPA) UNRAM
34	Hananingsih et al. (2021)	Jurnal Penelitian Pendidikan IPA (JPPIPA) UNESA
35	Trisnowati & Firdaus (2017)	Jurnal Pena Sains
36	Syahmel & Jumadi (2019)	Jurnal Penelitian Inovasi IPA

The linkages between articles were identified from their titles and abstracts. This was viewed in terms of analysis, which had a wide range of references so that the distribution of clusters became more effective. When viewed from the relationship between the title and the abstract, Vosviewer displayed words that appeared to form a related network and several clusters appeared. Therefore, every article that had the same words as other articles was included in the same cluster as shown in FIGURE 3.
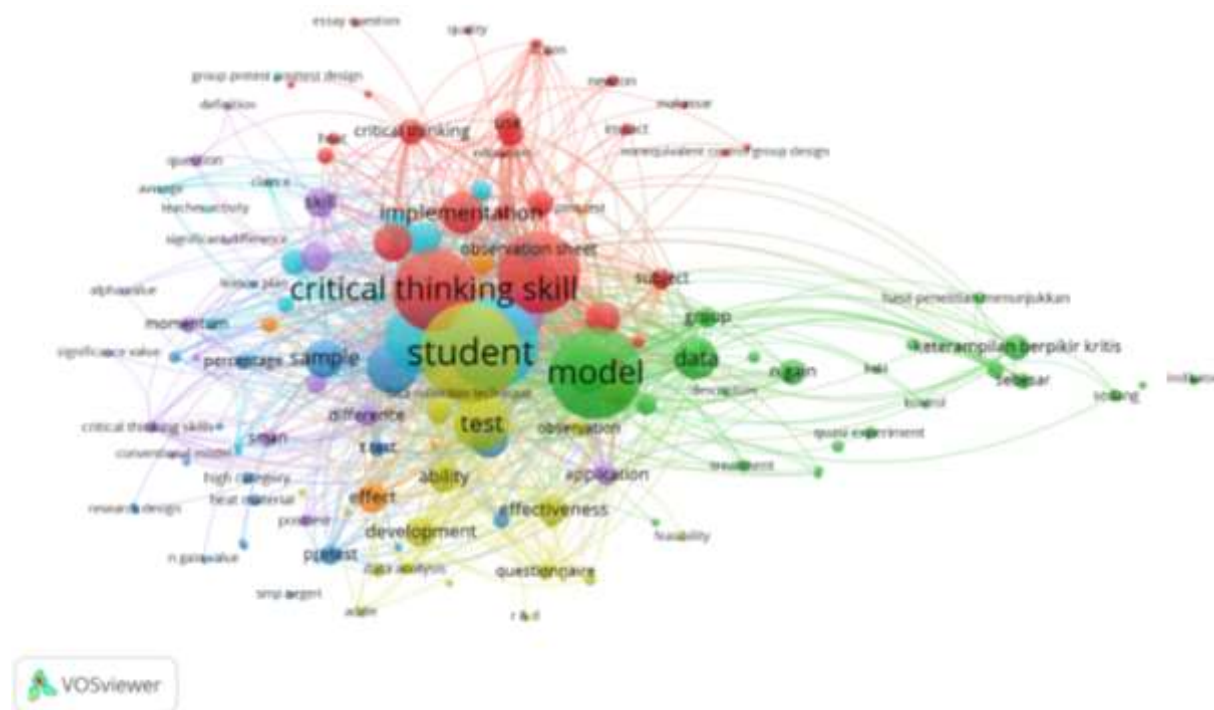
FIGURE 3. Screenshot of VOSviewer on word relatedness.

Based on the results of the analysis, there were 145 items/words found. Then a selection of keywords that described the research was carried out, and they were grouped into seven clusters. Based on the mapping in FIGURE 3, the keywords in each cluster are arranged as shown in TABLE 2.

TABLE 2. Clusters in Physics Critical Thinking Skills Research

Cluster colors	Keywords in cluster
Red	Analysis, cycle, essay question, quality, class, classroom action research, critical thinking, critical thinking skill, education, grade, heat, high school, impact, implementation, improvement, Newton, nonequivalent control group design, number, pbl, quality, research, senior high school, subject, temperature.
Green	Category, low category, abstract, approach, control, control class, data, description, indikator, keterampilan berpikir kritis, model, n-gain, pretest posttest, quasi-experiment, science process skill, SMP, treatment.
Blue	Good category, high category, practicality, student activity, validity, heat material, experimental class, high school student, n-gain value, percentage, practicality, pretest, research data, research design, sample, student activity, t-test, test instrument, validity.
Yellow	Ability, critical thinking ability, data analysis, feasibility, inquiry, ADDIE, data collection, development, effectiveness, field testing, independent sample t-test, inquiry, interview, observation, questionnaire, r & d, research method, sample t-test, student, teacher, test, validation.
Purple	Physics, conventional model, critical thinking skill, instrument, learning, learning model, momentum, physics, posttest, question, SMA.
Blue	Essay test, medium category, study, teacher activity, class X, experiment, group pretest design, impulse, increase, medium category, observation sheet, population, sampling technique, significance level, students' critical thinking, study, teacher activity, topic.
Pink	Data analysis technique, hypothesis testing, type, data collection technique, effect, mean, posttest, pretest, significant effect, type.

FIGURE 4 shows that there are the five biggest density visualizations, namely critical thinking skill, student, model, test, and implementation which have a strong relationship. If the words *student, model,* and *test* are highlighted, these words will be closely related to critical thinking skills. The word *student*
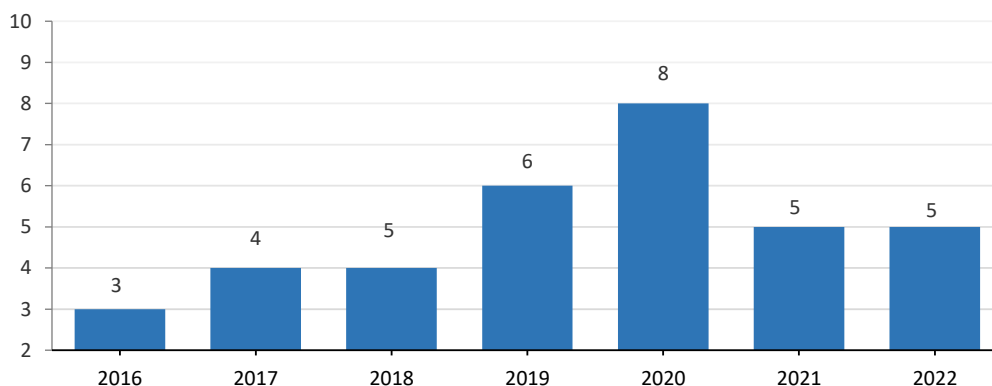
relates to research subjects, the word *model* relates to the treatment used in research, and the word *test* relates to data collection instruments in critical thinking skills research. Furthermore, the results of highlighting the word *implementation* is closely related to the teaching model to see how the effect of applying the teaching model as a treatment in critical thinking skills research.

FIGURE 4. VOSviewer display on density visualization.

The results of the mapping based on the title and abstract displayed by VOSviewer in FIGURE 4, if identification is carried out again by checking the article again, it can be described based on the year of publication of the article, type of research, research subject, material, treatment, data collection instruments, and data analysis. The process of analyzing critical thinking skills is carried out as follows.

Number of Publications

The number of article publications shows how often research is carried out in a certain period of time. FIGURE 5 shows that articles that examine critical thinking skills in physics in Indonesia has been found since 2016. FIGURE 5 also shows the number of publications for 2020 is the largest with a total of eight article publications. An increase in the number of publications in 2020 indicates that there has been an increase in the number of researchers who actively investigate critical thinking skills, especially in physics. Furthermore, for 2021-2022 there was a decrease in publications.

Most research results from the sensitivity of researchers to common problems that often occur around them. One of the most frequently encountered problems today is regarding the level of Indonesian students' critical thinking skills, which are still in the low category. Therefore, conducting research is believed to be the most effective way to overcome this problem. Through research, researchers can identify the most effective teaching designs or media that may be able to optimally improve students' critical thinking skills. So that the increasing number of research publications that investigate students' critical thinking skills will have a positive impact on the development of education in Indonesia. This statement is based on the ultimate goal of a study, which is to improve educational practice (Coburn & Penuel, 2016). Furthermore, a study will affect educational practice for several reasons, namely: (1) the findings can be called credible information that can be implemented by teachers; (2) the findings can be a fundamental basis for educational decision-making, in a national, local, or special institution; and (3) further findings can affect the way teachers think.

FIGURE 5. Distribution of the year of publication.

Types of Research

The research focus is determined by the type and research design used. TABLE 3 shows that quantitative research is the most widely used research method by researchers to investigate critical thinking skills. A total of 23 published articles used quantitative research methods. This finding is in line with previous studies which reported that researchers preferred quantitative research types to conduct research in the field of education, especially physics education when compared to other types of research (Nabilah & Jumadi, 2022).

TABLE 3. The Distribution of Critical Thinking Skills Research Articles in Physics Viewed from the Research Method

Research Methods	Total (n)
Quantitative	23
Qualitative	-
R & D	9
Mixed Method	2
CAR	2

In addition to revealing the type of research, this study also aims to explain the distribution of the research designs shown in TABLE 3 which were chosen by researchers. TABLE 4 shows that there are more quasi-experimental research designs than other research designs, namely as many as 13 article publications. In a quasi-experimental research design, researchers try to compare which treatment is most effectively used to improve critical thinking skills.

TABLE 4 The Distribution of Critical Thinking Skills Research Articles in Physics Viewed from the Research Design Method

Research Design			Total (n)
Quantitative	Experimental	Quasi-Experimental	13
		Pre-Experimental	5
	Non-Experimental	Descriptive	5
Qualitative		Descriptive	-
R & D		4D	2
		ADDIE	2
		Brog dan Gall	3
		Rowntree	1
		Thiagarajan	1
Mixed Method		Sequential Explanatory	2
CAR		Kemmis Taggart's	2

Research Subjects

When conducting a study, researchers need research subjects to test their hypotheses. FIGURE 6 shows that the most frequently chosen research subjects are grade X students of high school, followed by grade XI students of high school. This finding is in line with the research conducted by Lin et al.

(2014) which found that high school-level students dominated the research subjects. FIGURE 6 also shows that the least selected research subjects are university students. This finding is in line with the research conducted by Valverde-Berrocoso et al. (2020) which states that "student" is the third most searched keyword used for educational research.
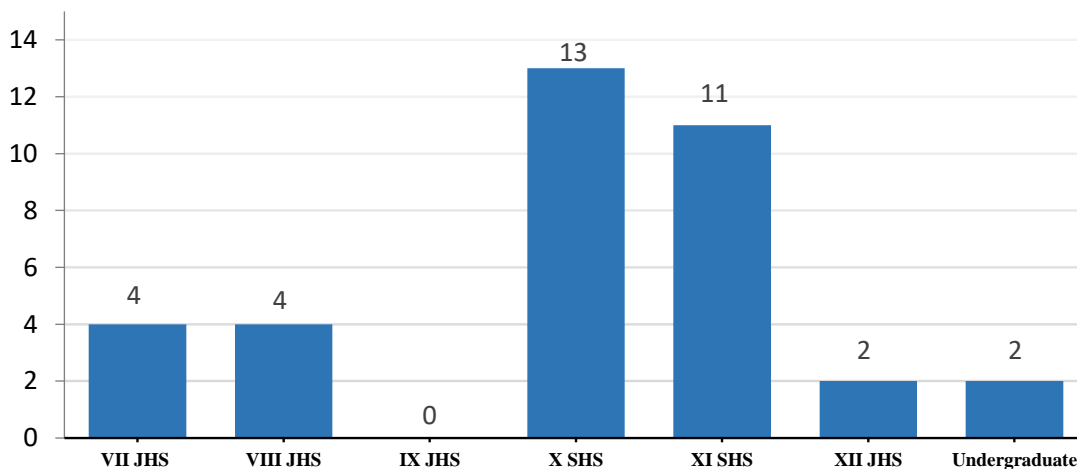

FIGURE 6. The distribution of critical thinking skills research articles in physics in terms of research subjects

In addition to displaying information about comparisons between the junior high school, high school, and tertiary education levels, FIGURE 6 also shows that the higher the level of a class at a certain educational level, the less often the class is chosen by the researcher as a research subject. grade X students of senior high school are the most frequently chosen research subjects, while grade XII students of senior high school students are the least frequently selected. This phenomenon is in line with the tendency of most schools to be selective in granting permission to researchers to conduct research in grade IX of junior high school and grade XII of senior high school. Due to the tight schedule of preparation for the National Standard School Final Examination (UASBN).

Physics Topics Selected When Conducting Studies

Physics is known as a difficult subject and is not liked by students, because it is directly related to experiments, formulas, calculations, graphs, and explanations of concepts (Darmaji et al., 2021) Based on TABLE 5, several topics are chosen by researchers to conduct research at junior high school, senior high school, and university. The material that is mostly used as a research topic is the material on Temperature and Heat with a total of seven articles published. Temperature and heat materials are one of the important materials studied in physics teaching. The research conducted by Fitriyani (2022) states that the average student's critical thinking skills in temperature and heat are still in the low category. This makes researchers in the field of physics education tend to choose the topic of Temperature and Heat as their research topic. Furthermore, TABLE 5 also shows that there are two other topics that are usually raised in the research, namely Newton's Laws and Static Fluids. Each of the two published five articles that examine critical thinking skills.

Treatments

Treatment aims to test the researcher's hypothesis or identify the importance of certain conditions for each parameter to be studied. (Sapitri et al., 2016) state that critical thinking skills can be developed or enhanced by providing treatment in the form of appropriate learning models. With reference to TABLE 6, the inquiry learning model with its various modifications is the treatment most widely used by researchers in critical thinking skills research. A total of 10 publications use the inquiry learning model.

TABLE 5 The Distribution of Critical Thinking Skills Research Articles in Physics Viewed from the Research Topics

Topics	Total (n)
Newton's laws	5
Momentum and Impulse	4
Effort and Energy	2
Static Fluids	5
Optical Tool	1
Solar system	1
Black Body Radiation	1
Temperature and Heat	7
Straight Motion	2
Elasticity	1
Vibrations, Waves and Sound	2
Substance Pressure and Its Application in Everyday Life	1
The Laws of Thermodynamics	1
Dynamic electricity	1
Simple Harmonic Vibrations	1
Heat Conductivity	1

TABLE 6 The Distribution of Critical Thinking Skills Research Articles in Physics Viewed from the Research Treatments

Treatments	Modification	Total (n)
Problem-Based Learning	Problem-Based Approaches	5
Inquiry	Argument-Driven Inquiry, Inquiry-Scaffolding, Guided Inquiry, Process Oriented Guided Inquiry Learning (POGI), Inquiry-Based Practice Equipment, Inquiry-Interactive Demonstration, dan Argument Based Science Inquiry (ABSI)	10
Problem-Solving	Problem-Solving Laboratory	3
Discovery Learning	Discovery Learning using Multiple Representations (DLMRs)	2
Group Investigation	-	2
Problem-Based Approaches	-	1
Project-Based Learning	-	1
Generative Learning	-	1
STEM	-	1
Predict Observe Explain	-	1
Blended Learning	-	1
Writing to Learn	-	1
Student Facilitator and Explaining (SFAE)	-	1
Self Directed Learning	-	1
Brain-Based Learning (BBL)	-	1
BW-ExPort learning	-	1
Unidentified	-	3

Data Collection Instruments

When conducting a study, researchers need instruments to help them collect data. The distribution of data obtained from research when viewed from the data collection instruments can be seen in FIGURE 7. Based on this image, it can be said that the test is the instrument most widely used by researchers to collect data on critical thinking skills. This finding is in line with previous studies which reported that researchers preferred tests as instruments to measure critical thinking skills (Nabilah & Jumadi, 2022). Collecting data by using tests is considered more objective when compared to questionnaires and observations.
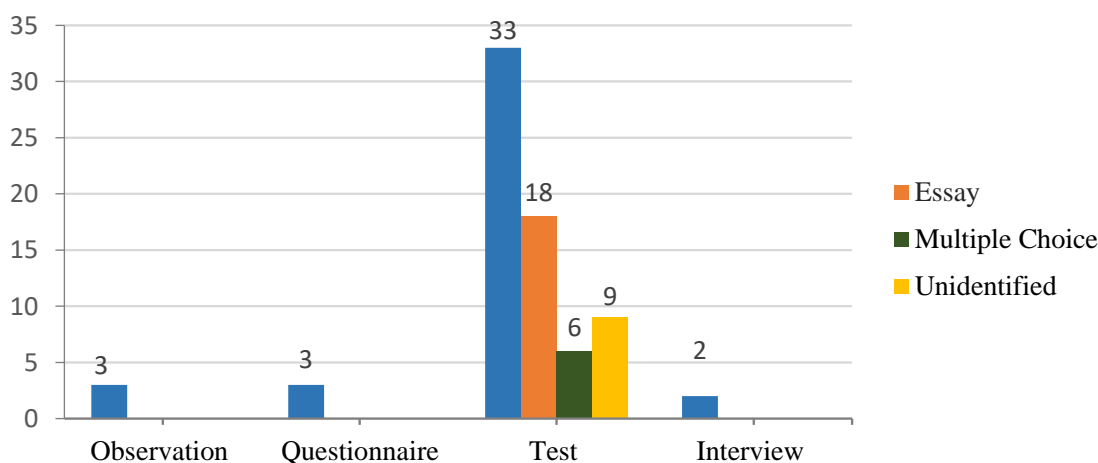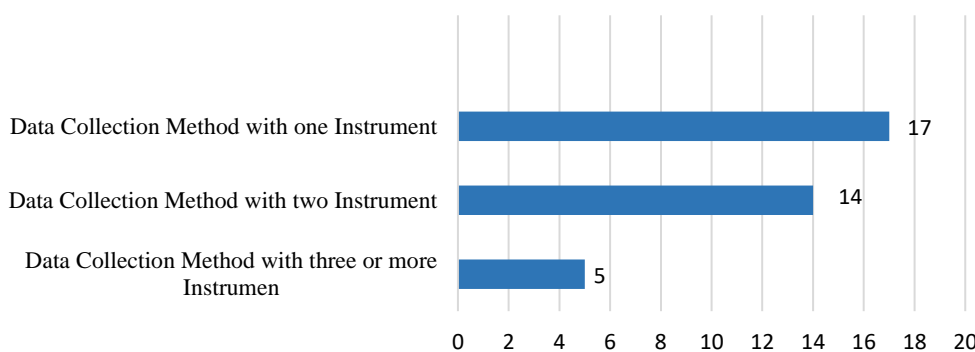
FIGURE 7. The distribution of critical thinking skills research articles in physics viewed from the research data collection instruments

FIGURE 7 also shows that the essay test is the most dominant test used by researchers to measure critical thinking skills. Essay questions have demands on students who work on describing and organizing their knowledge so that students can freely solve problems on questions (Tim Pusat Penilaian Pendidikan 2019). In addition to the description test, there are also multiple-choice tests that are often used by researchers to measure critical thinking skills. The multiple choice test is chosen because it has several advantages, including that it can measure various levels of knowledge, it can be corrected easily, and it is the right form for administering tests with a large number of test-takers (Tim Pusat Penilaian Pendidikan 2019).

FIGURE 8. The distribution of critical thinking skills research articles in physics viewed from the research data collection instruments

The distribution of data collection instruments can also be seen in FIGURE 8, which shows that researchers, in collecting data, used not only one instrument but also more instruments. The data collection method with one instrument is the most dominant used by researchers to measure critical thinking skills.

Data Analysis Methods

The accuracy of the selection of methods for data analysis will determine the level of validity of a study. TABLE 7 shows that the T-test is the most widely used method of data analysis, with a total of 10 articles published. This finding indicates that researchers often use the t-test to compare two different samples used to determine the average difference between two groups or classes. The data tested were data obtained from the N-Gain of each student in the control class and experimental class (Sari et al., 2022).

TABLE 7 The Distribution of Critical Thinking Skills Research Articles in Physics Viewed from the Data Analysis

Data Analysis	Total (n)
SEM	1
Percentage	3
N-Gain	9
Aiken V	1
T-Test	14
Uji Mc Nemar	1
MANOVA	3
Descriptive Comparative	1
ANOVA	2
Descriptive Qualitative	1

Furthermore, the data from TABLE 7 also shows that the data analysis technique using N-gain is also often used by researchers. A total of nine out of 36 articles mention this. The researchers used N-Gain to find out the increase in critical thinking skills of both classes based on the scores from the pre-test and post-test in the control class and the experimental class. Each student in the control class and the experimental class was calculated for his or her N-Gain, and then the average N-Gain for the two classes was calculated (Sapitri et al., 2016).

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the research trend of physics critical thinking skills in Indonesia which was published from 2016 to 2022 shows that the research trend of physics critical thinking skills in Indonesia increased in publications in 2020. The physics material that becomes the research trend is Temperature and Heat with the most research subjects being grade X students of high school. The tendency of research on physics critical thinking skills in Indonesia tends to use quantitative research methods with quasi-experimental research designs and uses data collection instruments in the form of tests. As for the data analysis, the dominant data analysis used by researchers is the t-test. The results of a systematic research literature review with a total of 36 articles can be used as a reference for further research, especially in research on critical thinking skills in physics in Indonesia.

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