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The Trend of Research Critical Thinking Skills in Physics Education Journal Evolution in Physics Education Journals across Indonesia: From Research Design to Data Analysis

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Abstract
Critical thinking skill is important that needs to be developed in 21st-century education. This research aims to conduct a content analysis of articles published in physics education journals throughout Indonesia from 2017 to 2022, with a focus on critical thinking skills. The findings of this study show an increase in the number of publications related to critical thinking skills each year. The most used research design is quantitative research, with the main research subjects being high school students in grades X dan XI. The most frequently used physics material topic is fluid and mechanics. The analysis method most used by researchers is N-gain and t-test. Therefore, the findings of this research recommend that future critical thinking skills research consider variations in research design, research subject, data analysis method, and physics material topic.

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1. Introduction

Critical thinking skills play a significant role in the 21st century. In the digital era, life becomes increasingly complex, and the environment is constantly changing, making critical thinking skills a navigational tool for individuals to adapt to these changes. Moreover, critical thinking skills help individuals understand themselves, their motivations, and their life goals, which, in turn, can enhance their growth and happiness. Furthermore, critical thinking skills are the key to success in the 21st-century workplace. Therefore, it is essential for teachers to facilitate and train students to develop critical thinking skills.

Critical thinking skills are crucial in learning physics because physics involves experimentation, creativity, and problem-solving [1]. Physics, as a tool of thinking, investigates the nature of the universe, analyzes it, and understands it [2]. By learning critical thinking skills, students become analytical thinkers who evaluate various claims and sources of information [3]. Critical thinking skills are also a domain of thinking skills measured in physics learning [4]. Additionally, analyzing possibilities and uncertainties is an essential aspect of critical thinking skills relevant to daily life and science [5]. Therefore, teaching critical thinking skills in physics class can help students develop valuable skills that will benefit them in their studies, lives, and careers in the future.

The ability to think critically is a vital skill in the 21st century and has become one of the objectives of physics learning [6]. There are several ways to develop student's critical thinking skills through physics learning, namely by developing logic thinking through hypothetical and data-based thinking processes, research-based learning, experimental and analytical learning that helps students develop critical thought skills, as well as problem-solving and decision-making learning [7]. Therefore, the development of critical thinking skills is essential, not only to improve student's academic skills but also to help them in their ability to evaluate information in societies that are now easily accessible.

According to the search results, there are several factors causing low critical thinking skills among Indonesian students in physics learning. One of the main reasons is the lack of student involvement in learning [5]. Additionally, there is a lack of emphasis on building basic skills, drawing conclusions, and arranging strategies [8]. The PISA analysis also reported that Indonesian students have low abilities in linking science to everyday life, interpreting data, analyzing and solving problems, conducting investigations, drawing conclusions based on logical reasons, and understanding complex information [1]. Another factor is the impact of illiteracy or a lack of interest in reading on students [9]. To improve critical thinking skills, teachers should act as facilitators and provide meaningful learning resources, such as the problem-based learning 4C model [10].

Information on research trends on critical thinking skills of students in the context of learning physics in Indonesia is still limited. Several studies have been conducted to explore the perception and attitude of teachers towards the disposition of critical thinking skills at the secondary school level [11]. The results of these studies indicate that teachers in Indonesia have difficulty teaching critical thinking skills in the context of physical education [12]. Therefore, it is important to conduct research to deepen trends in the development of critical thinking skills of students in learning physics in Indonesia.

Research on critical thinking skills in Indonesia has been growing in recent years. Many studies have been conducted to investigate how physics teaching can improve students' critical thinking skills. However, so far, there has been no comprehensive study on the trends of research on critical thinking skills in physics education journals in Indonesia. Therefore, this study aims to investigate the trends of research on critical thinking skills in physics education journals in Indonesia. This study will answer several questions, namely: (1) How many studies on students' critical thinking skills in physics learning have been conducted in the last 5 years (2017-2022)? (2) What is the design of research on students' critical thinking skills in physics learning in Indonesia? (3) What is the variety of research subjects on critical thinking skills in physics learning in Indonesia? (4) What physics topics are used in studies on students' critical thinking skills? (5) What data analysis methods are used in studies on students' critical thinking skills?

This current study differs from previous studies on critical thinking skills in several aspects. Firstly, the study focused on articles published between 2017 and 2022, all of which were accredited by the Science and Technology Index (SINTA). Secondly, the study investigated all articles with a primary focus on critical thinking skills. Thirdly, various content analysis parameters were used.

2. Methods

This research will essentially analyze research findings that have been published in scientific journals in Indonesia using the content analysis method. The design of this research is like the research method used by Sesotyarini and Fauzi [13]. The data used in this study was obtained from the content analysis of physics education articles registered in the Science and Technology Index (SINTA) until April 2023. SINTA (https://sinta.kemdikbud.go.id/) is a platform developed by the Indonesian Ministry of Research, Technology, and Higher Education to measure the quality of science and technology in Indonesia. There are 33 physics education scientific journals registered in the SINTA database, which are grouped into six categories from SINTA 1 to SINTA 6. The higher the SINTA ranking, the lower the journal quality. In this study, the articles used were scientific articles published in physics education journals with SINTA 1, SINTA 2, and SINTA 3 categories. Out of 116 collected articles, 63 met the inclusion criteria and will be analyzed using the content analysis method.

The instrument used as a guide for analyzing the articles is presented in Table 1. Six content analysis aspects were observed in the articles, including (1) the number of articles published each year, (2) the type of research, (3) the research subjects, (4) the physics topics used in the research, (5) the treatment, and (6) the data analysis. Aspects (2), (3), and (6) are further divided into sub-aspects as shown in Table 1.

In this study, the collected articles were classified based on predetermined aspects. The decision-making process for classification was based on the information provided by the authors in the abstract, methodology, and discussion sections of the articles. Subsequently, the collected data from the classified articles were presented in the form of bar diagrams as one way to visualize the information contained in this research. This data collection method is expected to provide clearer and more systematic information related to the research topic under discussion. The results of this study are expected to make a significant contribution to the development of scientific knowledge in the related field.

Table 1. The Aspects and Categories of Content Analysis Used in the Research

Aspects	Categories	
Types of research (2a)	A-1 R and D	A-4 Qualitative Research
	A-2 CAR	A-5 Mixed Method
	A-3 Quantitative Research	
Types of quantitative research (2b)	B-1 Quasi experimental design (QED)	B-4 Expostfacto Design (ED)
	B-2 Pre-experiment (PE)	B-5 Survey Research (SR)
	B-3 True-experiment (TE)	
Research subject	C-1 Class VII JHS	C-5 Class XISHS
	C-2 Class VIII JHS	C-6 Class XII SHS
	C-3 Class IX JHS	C-6 Undergraduate
	C-4 Class X SHS	
Data Analysis	D-1 Mean	D-5 N-gain & t-test
	D-2 Percentage	D-6 Correlation
	D-3 N-gain	D-7 Anova
	D-4 t-test	D-8 Manova

3. Results and Discussions

3.1. Number of Publication

The number of research articles can indicate the frequency of research on a particular topic within a specific period. Based on the data in Figure 1, research on students' critical thinking skills had the highest number of publications in 2019, with 13 articles published, while the lowest number of publications occurred in 2017, with only one article published. On average, the number of research articles on critical thinking skills from January 2017 to December 2022 was around 10-11 articles per year. This data provides a clear overview of the frequency of research conducted on students' critical thinking skills within the specified time period.

The interest of a researcher in a topic depends largely on their sensitivity to educational issues that require solutions. Recent research indicates that critical thinking skills in Indonesia are still low, which impacts the quality of education [9]. One interesting topic that attracts researchers' attention is critical thinking skills since they are considered essential skills for meeting the demands of the 21st century [14]. Integrating critical thinking skills into the national education curriculum is crucial for improving the quality of education in Indonesia [15]. Therefore, research on critical thinking skills is crucial and strategic for enhancing the quality of education in Indonesia.

3.2. Types of Research

Research on critical thinking skills has a dominance of quantitative research compared to qualitative research. This is in line with the preference of educational researchers for quantitative research methods over qualitative methods, as reported by Durak et al., [16] However, the use of qualitative research methods is increasing in physics learning research. In this context, qualitative research is considered capable of providing more in-depth and comprehensive information about the development of critical thinking skills in physics learning. As a result, qualitative research can make an important contribution to developing our understanding of the aspects of critical thinking skills in physics learning, thereby helping to improve the quality of physics learning in the future.

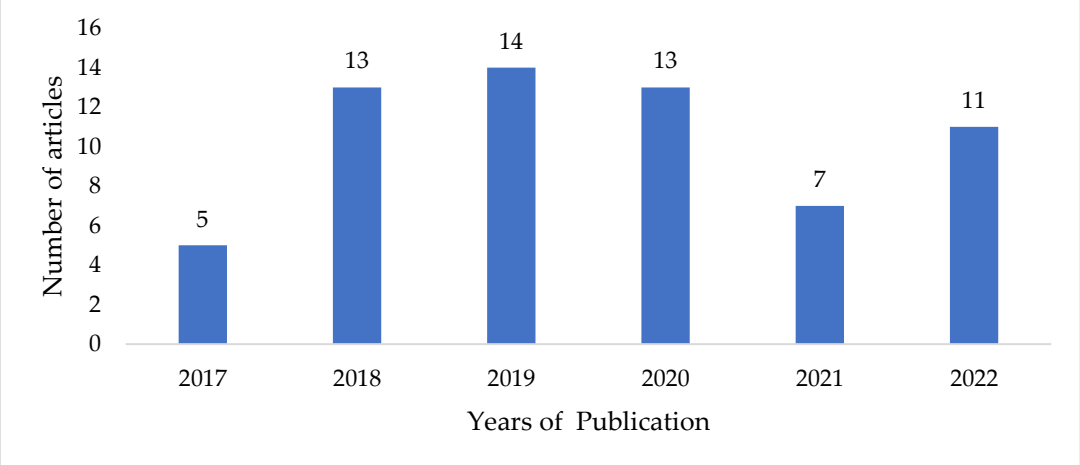

Figure 1. The Trend of Studies on Critical Thinking Skills (Last 5 Years)

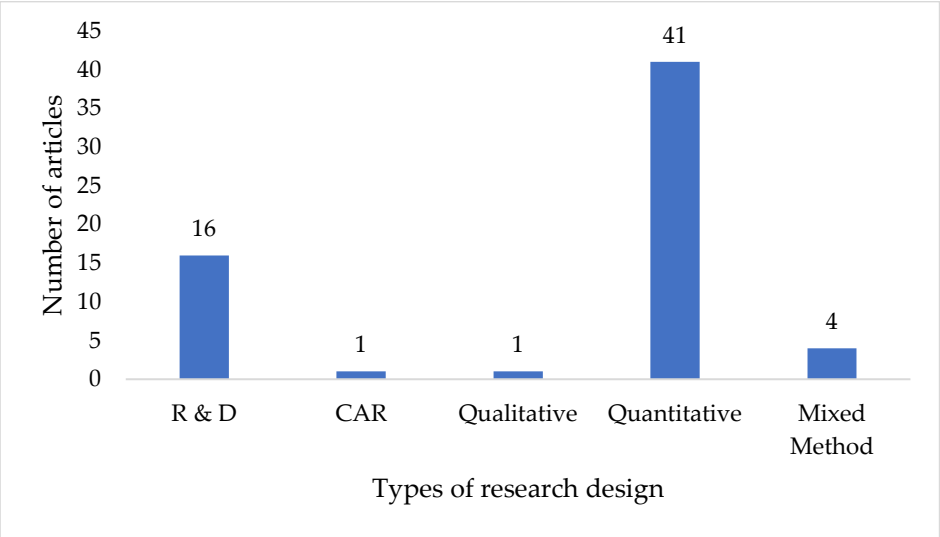

Figure 2. The Types of Research Designs for Improving Critical Thinking Skills

The type of research design determines the focus of the study. Based on Figure 2, one study discussed the challenges and possible solutions in using qualitative methods in physics education research [17], The study aimed to provide a space to examine and challenge current practices, learn how the qualitative landscape has changed over decades, and highlight the latest approaches in qualitative methods. Another study discussed the various research methods used in physics education research, including qualitative, quantitative, and mixed methods, which help researchers understand physics education phenomena and advance efforts to produce better physics education research [18]. However, the majority of physics education studies are still quantitative in nature, and the use of qualitative methods is still limited [19]. Therefore, there is a need for continued research into the use of qualitative approaches in physics education research, as well as the development of new and innovative methods to address the challenges faced by researchers in this field (Figure 3).

3.3. Research Subject

Critical thinking skills of students continue to be empowered in physics learning. Based on the above review, the research design used is quasi-experimental to determine the appropriate methods and ways to empower students' critical thinking skills.

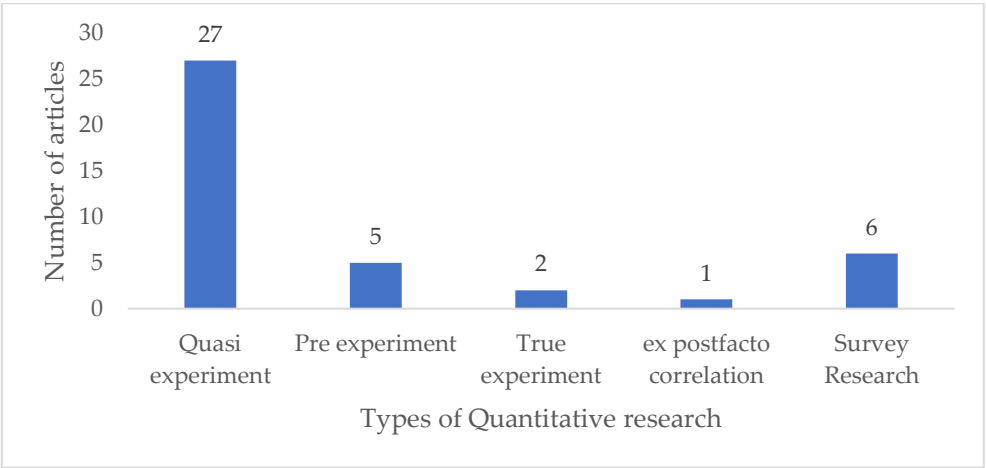

Figure 3. The Distribution of Quantitative Research on Critical Thinking Skills

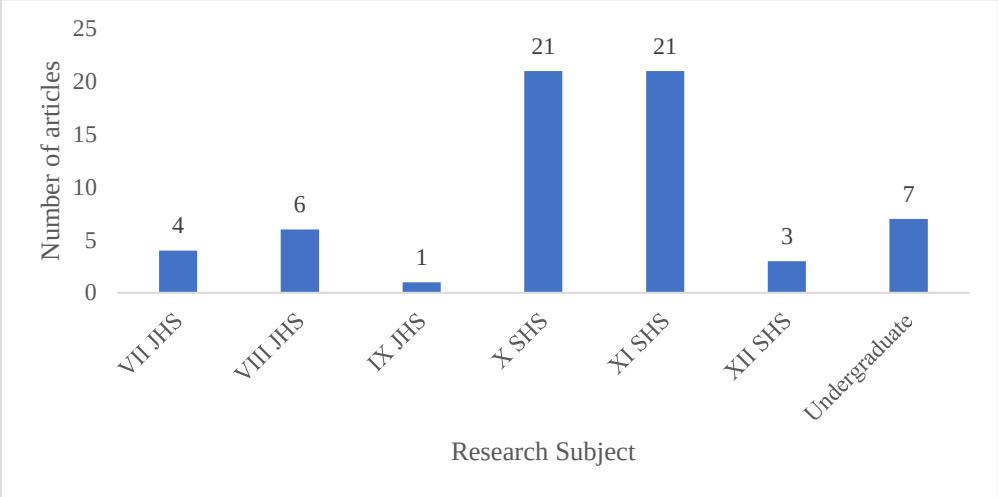

Figure 4. The distribution of research subjects on critical thinking skills

Based on Figure 4, the research subjects chosen to develop critical thinking skills varied from junior high school students to university students. The most used research subjects were high school students in grades 10 and 11, while the number of studies involving junior high school students in grade 9 and high school students in grade 12 was the least involved. These research findings support the findings of Nabila & Jumadi that research samples in physics studies generally involve secondary school students [20].

Based on Figure 4, research subjects in grade IX of junior high school and grade XII of senior high school were the least chosen. This could be due to considerations from the school, where grade IX of junior high school and grade XII of senior high school are often used as classes to prepare for exams. Therefore, schools may be reluctant to involve students in research that could disrupt exam preparations [13].

3.4. The Selected Physics Topics in The Research on Critical Thinking Skill

Based on Table 2, physics is a subject that covers many learning topics, from easy to difficult material. However, in Indonesia, research has explored more on students' critical thinking skills in the topic of fluids, while material and its changes, as well as electricity and magnetism, are the least studied. These findings are different from Uzunboylu & Asiksoy's research, where studies in 2008-2013 explored more on mechanics topics (kinematics and dynamics), and the least was nuclear physics [19]. Therefore, all topics in physics have not yet been fully explored in physics learning to improve students' critical thinking skills.

Table 2. The Selected Physics Topics in The Research on Critical Thinking Skill

Topic	Number of articles
Kinematics and dynamics	*5*
Work and Energi	*3*
Impulse and Momentum	*3*
Fluid	*8*
Temperature and Heat	*7*
Waves	*5*
Electric and Magnetic	*2*
Material and change	*1*
Optics	*4*
Not mentioned	*25*

There has been no previous research that discusses the reasons why fluid topics become the primary choice of researchers in Indonesia in improving students' critical thinking skills. This topic covers complex concepts and principles of pressure, buoyancy, and fluid dynamics that require students to think critically and apply their knowledge to solve problems. Therefore, the fluid topic was chosen to improve students' critical thinking skills because it provides challenging and engaging learning experiences and encourages students to think deeply and critically about the learning material. In addition, fluid topics are also highly relevant and practical, widely used in the real world, and can help increase the popularity of physics learning among students.

3.5. Types of Treatments

The treatment in research aims to test hypotheses or evaluate the impact of certain conditions on the variables being studied. Based on Table 3, problem-based learning (PBL) and inquiry learning (IL) approaches are more commonly chosen by researchers in efforts to enhance students' critical thinking skills.

Table 3. The type of treatment/independent variable selected by researchers in critical thinking research

Treatments/independent variable	Number of articles
Problem-Based Learning	*15*
Cooperative Learning	*5*
STEM	*2*
Etno-STEM	*2*
Discovery learning	*2*
Inquiry Learning	*12*
Problem-solving	*2*
Blended learning	*3*
Worksheet student, medium, material learning	*20*

The PBL approach actively engages students in solving real-life problems that require critical thinking skills and application of knowledge. In PBL, students are presented with challenging and interesting problems that force them to find solutions using critical thinking skills [21][22]. On the other hand, IL involves students in asking questions, investigating, and exploring topics to develop critical thinking skills. Both approaches can improve students' critical thinking skills by providing challenging and interesting experiences that demand deep and critical thinking of the learning material. Additionally, these approaches are student-centered and promote active learning, which has been shown to be effective in improving critical thinking skills compared to conventional methods [23].

3.6. Data Analysis Methods

The validity of a research study is determined by the researcher's accuracy in choosing the appropriate data analysis method. From Figure 5, it is shown that out of 27 quasi-experimental studies, only 4 studies used ANOVA analysis. Researchers tend to use n-gain and t-test as data analysis methods in their studies. The t-test is used by researchers to test the significant difference between the means of two groups, for example, between the experimental and control groups, or between the means before and after treatment. Meanwhile, n-gain is used to measure treatment effectiveness.

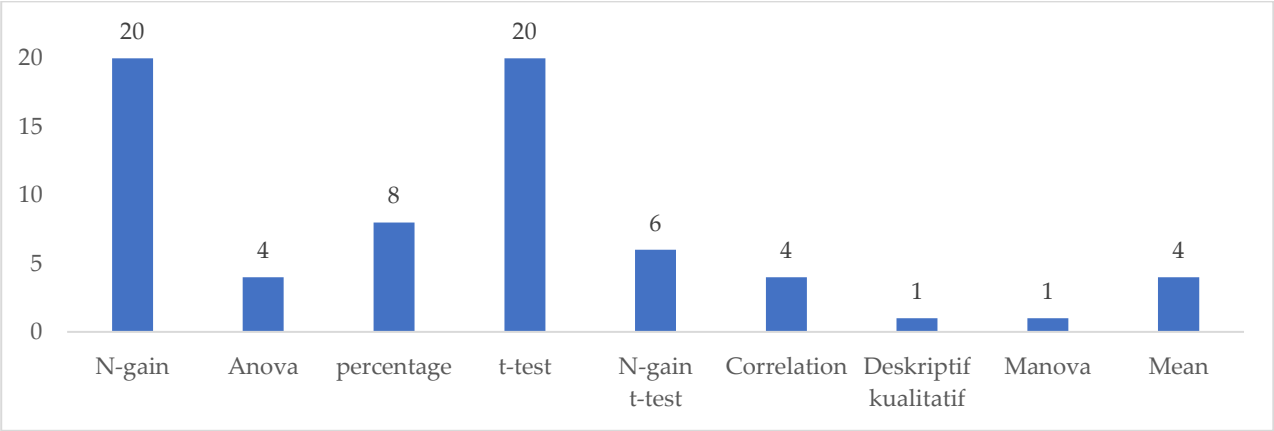

Figure 5. The Distribution of Data Analysis Methods in Research on Critical Thinking Skills

The use of t-test and n-gain is generally used to analyze and evaluate the effectiveness of treatments in physics learning [24]. However, the excessive use of these analyses can reduce the validity of the research, as has been revealed by previous studies [25]. Therefore, researchers should choose the appropriate data analysis method according to the type of data obtained in their research.

4. Conclusion

This study conducted an analysis of articles published in physics education journals in Indonesia from 2017 to 2022, with a focus on critical thinking skills. A trend of increasing research on critical thinking skills was found each year. In the content analysis of 68 articles, it was found that quantitative research design was the most dominant. The most chosen research subjects were 10th and 11th grade high school students. Problem-based learning and inquiry learning were frequently used as treatments in the studies, while fluid topics in physics were the most frequently selected. N-gain and t-test were the most used data analysis techniques. Based on the findings, future research is recommended to (1) increase the frequency of qualitative, mixed-method, and R&D studies to produce products in improving critical thinking skills in physics learning, (2) vary physics materials, methods, and appropriate data analysis techniques to increase the validity of research, and (3) select the most suitable test for research hypotheses.

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