Literature Review of Students' Critical Thinking Skills in Physics Education with Bibliometric Analysis

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Abstract. This study aims to analyze the application of critical thinking skills in physics education through bibliometric distribution with literature study research methods are used with bibliometric analysis with a description of topic developments including the number of publications, articles, research, approaches, and productivity. Data obtained from the Scopus database, with the keyword "Critical Thinking in Physics Education" in the range of 2018-2023 as many as 226 documents. However, the topic of critical thinking has the opportunity to be studied more deeply and has great opportunities on physics education issues in various parts of the world because it still has a relationship with another keyword in physics education.

1. Introduction

In the midst of an endemic transition in Indonesia, education in Indonesia is entering the 21st-century by focusing on three main concepts, namely 21st-century skills, a scientific approach, and authentic assessment. Along with the development of technological and scientific advances that create new relationships between society and science that produce controversial issues [1]. Education is an effort that is carried out consciously and planned in creating an active learning process so that it can develop the potential of students in dealing with changes that occur [2]. Education is a means to develop the potential resources of human strength [3]. One of the 21st-century skills developed is critical thinking skills that focus on patterns of decision-making about something that is believed [4]. Critical thinking skills can be developed through education in particular, through learning physics.

Physics underlies the development of science and technology through problems related to natural phenomena which are also related to the systematic exploration of nature [5]. Through learning physics, students are demanded quality in learning so that students can face the development of science and technology. Physics learning is naturally related to phenomena, causes, consequences, and their use. Through learning physics, students can solve and discover why and how a phenomenon can occur. Zemansky stated that this is an empirical science which means that everything studied in physics is based on nature and its phenomena [6]. Thus, the development of critical thinking is generally claimed to be the goal of science. Mastery of the material by students can be shown through the process of thinking. The thought process is one of the stages in learning activities that is important and influences the learning outcomes achieved [7].

To think openly, critical thinking can divert important issues and reveal problems by obtaining and assessing relevant information [8]. So that critical thinking skills can help students understand challenges and develop alternative problem-solving strategies with problem-solving stages. Critical thinking skills are a person's skill process in formulating answers or finding solutions in solving a problem [9]. Critical thinking involves the process of understanding, analyzing, evaluating information, and creating rational decision reasons. According to [10]Critical thinking has more than one set of sub-skills in which, active attitudes are reflective and situated within a constructivist theoretical perspective. Critical thinking skills are influenced by several factors such as the learning environment, learning styles, and social factors that are mutually sustainable. The learning environment can support students' critical thinking skills which are supported by learning styles in understanding and applying physics

concepts well. In addition, other student skills such as scientific literacy skills also require critical thinking skills in the process. [11].

Several factors influence learning, which is mainly dominated by low student motivation and interest in learning [12]. Students' critical thinking skills are influenced by several factors such as the learning environment, learning style, motivation, and social factors that influence each other [13]. The learning environment as a facility can help students improve critical thinking skills. Appropriate learning styles can help students understand and explore physics concepts well. Motivation can affect students' skills in understanding and participating actively in practicing critical thinking skills. In addition, social factors which include student interactions with friends and teachers also affect students' critical thinking skills [14].

Research on critical thinking skills has previously been widely carried out in scientific publications, however, research using bibliometric analysis methods has not been sufficiently studied. Research using the bibliometric analysis method on critical thinking skills using the Scopus index. This is because the Scopus journal is a scientific literacy and quotation data center. Scopus is a part of the international scientific publication, Elsevier. In the Scopus database, there are about 22,000 titles from 5,000 publishers around the world [15]. In addition, critical thinking skills are related to the development of students so an in-depth study is needed.

Bibliometric mapping is widely used in studying the interaction between science and technology as well as investigating the development of knowledge in certain fields and producing maps. Mapping is in the form of visualizing maps on topics from science that can help researchers, visualization is done with the help of VOSViewer software. VOSViewer is one of the software programs developed for making bibliometric maps. VOSViewer functions to visualize and explore maps based on network forms that show relationships in citing a publication [16].

Based on these problems, this research was conducted to examine trends in the development of scientific publications which include the number of journal publications, researcher productivity, top articles that are widely cited, relationships between research topics, research trends, and frequently researched topics regarding critical thinking during 2018-2023 from the Scopus database by conducting a bibliometric analysis with the keywords "Critical Thinking" and "Physics Education". It is hoped that this research can provide information about the development of research methods on critical thinking skills in the 2018-2023 range so that it can be used as further research analysis regarding the relationship of students' critical thinking skills with learning physics.

2. Methods

This research was carried out using a literature study using the bibliometric analysis method which is based on research conducted in the period 2018 to 2023 by describing topic developments, such as the number of publications, articles, research, approaches, and topic productivity. The data source was obtained from the Scopus database with the keyword "Critical thinking on physics education". Based on the search results for research sources, 226 documents were obtained on the topic of critical thinking. The results of the bibliometric mapping on VOSViewer which is needed in the Co-Occurance analysis reveal the discussion of research topics statistically with the provision of pairs of more than two related keywords [17].

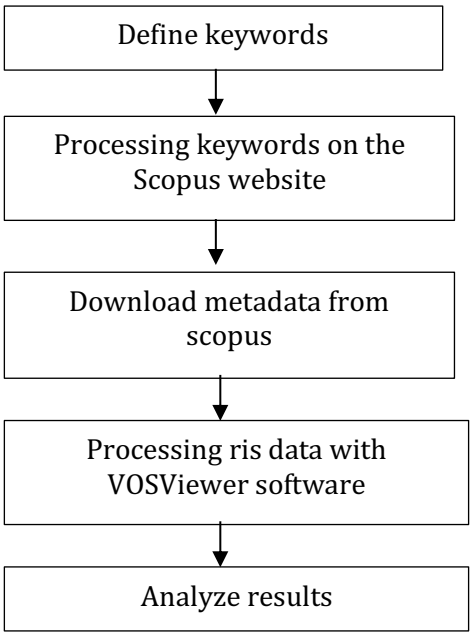

Figure 1. Stage of bibliometric analysis

3. Result and Discussion

Data search was carried out through Scopus metadata in May 2023 with a range of 2018-2023 and obtained 226 documents regarding critical thinking skills in physics learning The metadata results are processed through the VOS Viewer which shows an unstable writing trend from year to year as shown in Figure 2. This is because the data downloaded from Scopus is the latest published data conducted in the 2018-2023 range. In 2018, there were 27 published articles, and there was an increase in 2019 as many as 59 articles as the peak of the trend of publishing articles on critical thinking skills in physics learning and decreased in 2020 to 46 articles. However, it increased again in 2021 by 50 publications and has again decreased until now.

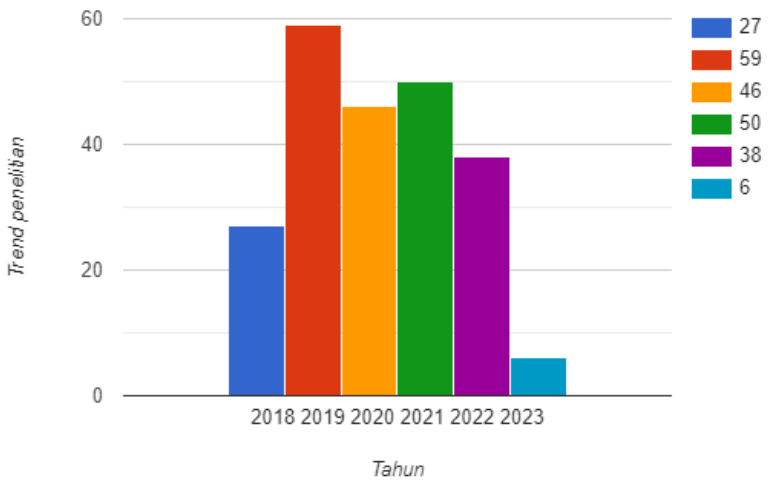

Figure 2. Research trends in the last six years

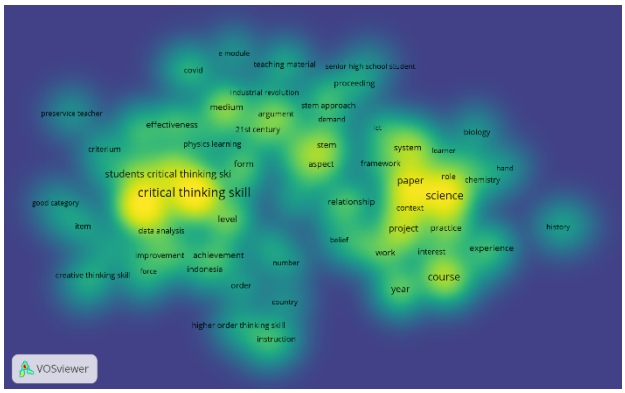

Figure 3. Density visualization on the topic of critical thinking skills

Based on metadata analysis through the VOS Viewer software shown in Figure 3. Research developments show that the topic of critical thinking skills is brightly colored, which means that the discussion of the topic becomes the center of attention and is lively for discussion. Researchers in various parts of the world widely study the topic of critical thinking skills in physics learning through the publication of Conference Papers of 61.9% or reaching 140 publications and only 0.4% for the review type publications shown in Figure 4. Researchers are much interested in publishing topics in notes.

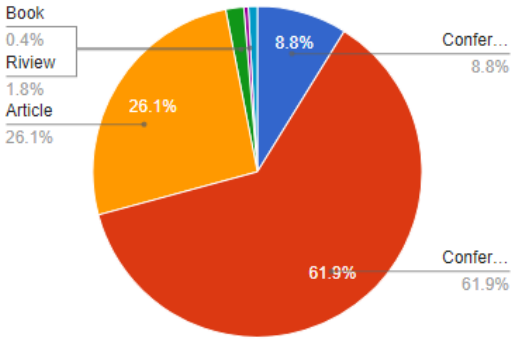

Figure 5. Types of document publications

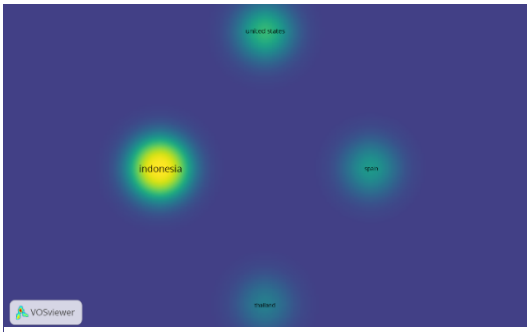

Figure 4. The density of document distribution with country variations

VOS Viewer analysis was performed based on the number of documents published from the author's country (Figure 5), research was dominated by researchers from Indonesia with a total of 115 documents, other countries that also explored the topic of critical thinking skills were Malaysia, Brazil, Spain, Thailand, and the United States however, the number publication of documents is not done enough. This is enough to prove that researchers from various countries around the world are interested in discussing critical thinking skills in physics learning so updates are often carried out every year. In figure 6 shows the top authors and research clusters conducted and demonstrated research productivity regarding critical thinking skills in physics learning which is quite popular in Indonesia. The domination of the author is carried out by Suhandi A who leads cluster 1 [18].

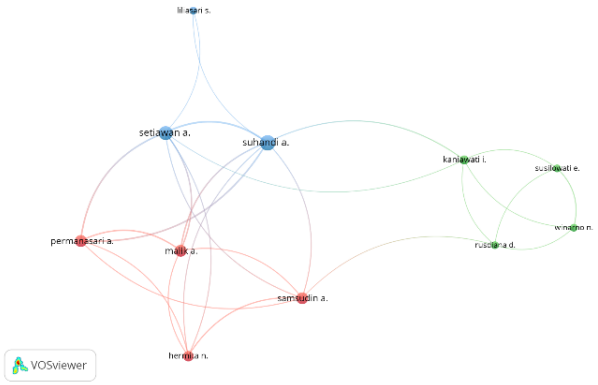

Figure 6. Most researchers on the topic of students' critical thinking skills

The colored circle in the visualization results shows the keyword items that appear in the title and abstract, the size of the circle also shows the intensity of research carried out related to the topic. The larger the circle size, the more keywords that appear more frequently. Based on the search results with the keywords critical thinking skills in physics learning that appear in several research articles, it is indicated by the appearance of the keywords critical thinking in purple and critical thinking skills in green (Figure 7) which means that the keywords critical thinking skills and thinking Critical criticism has appeared in titles and abstracts in several scientific articles. There are 5 clusters namely red, green, purple, yellow, and blue which show the relationship between one topic and another. Critical thinking skills and critical thinking are connected with physics learning in the blue cluster which shows that physics learning influences critical thinking skills.

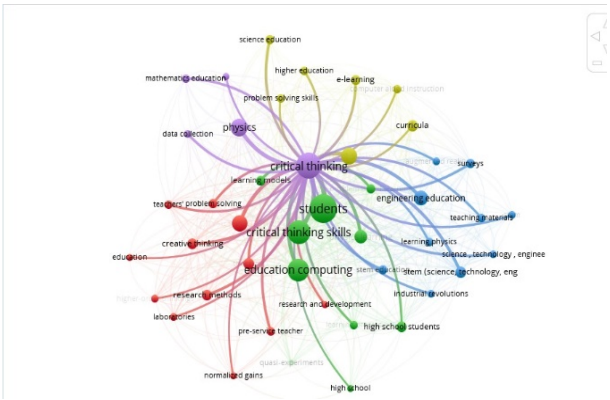

Figure 8. Visualization of keyword relationships with VOSviewer

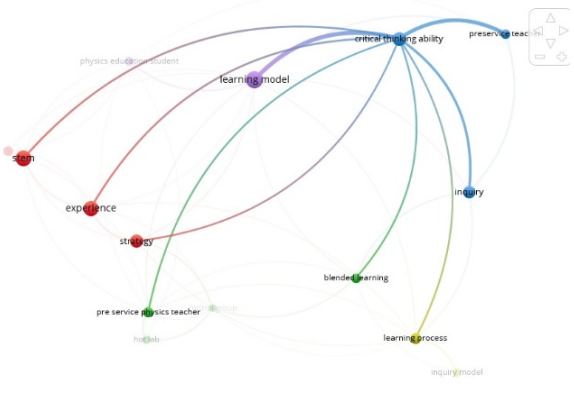

Figure 7. Visualization of the relationship between learning models and critical thinking skills

If we focus on mapping more specific relationships, you can find research trends in Figure 8. Figure 8 shows that the learning model used has a relationship to critical thinking skills which gives rise to 5 clusters. In the blue cluster, critical thinking skills are connected to the inquiry learning model and pre-service teacher.

4. Conclusion

The implementation of critical thinking skills in learning physics has a broad relationship. Based on the results of the VOSViewer mapping, it shows that there are many relationships in each cluster between the words critical thinking skills and learning physics. So, based on these results, it can be concluded that the relevance of implementing critical thinking skills in learning physics is dominated by science.

The trend of research on critical thinking skills in learning physics from year to year has decreased and increased unstable, however, development is still being carried out every year with 61.9% in the form of conference paper publications. Much research related to these keywords has been carried out in Indonesia with a total of 115 publications. In addition, if the relationship between keywords and other variables is narrowed, shows that critical thinking skills in physics learning are also influenced by the learning model used and also the learning media used as a means. The content of research on critical thinking skills is dominated by learning science and physics and meanwhile, the most prolific writer is Suhandi, A. The results of this study are expected to be applied as a consideration for teachers in applying critical thinking skills in learning, especially in learning physics. The research was limited to conducting an analysis based on the title and keywords from the Scopus database. Therefore, estimates of the strength of the relationship cannot be ascertained. In addition, it is unclear how far critical thinking skills are implemented in different parts of the world.

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