

Bibliometric Analysis of the Application of Open-Ended Approach in Improving Critical Thinking Skills

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ABSTRACT: This study aims to map the trend of scientific publications on applying the open-ended approach in improving students' critical thinking skills. This study uses a bibliometric analysis method on articles published from 2019–2024. Data were collected through Google Scholar with the help of the Publish or Perish application and visualized using VOSviewer. After the screening process, 15 relevant articles were obtained. The analysis results show that interest in the open-ended approach to improving critical thinking is increasing, with a primary focus on mathematics and science subjects at the elementary and secondary school levels. This finding indicates the need for cross-disciplinary collaboration and developing a more systematic and contextual open-ended learning model.

Keywords: Bibliometric Analysis, Critical Thinking Skills, Open-Ended Approach.

I. PENDAHULUAN

Critical thinking skills are important in mathematics learning because they enable students to analyze problems deeply, evaluate arguments, and draw logical conclusions. According to Utami (2022), critical thinking in mathematics includes assessing truth, weighing relevant evidence, and identifying flawed arguments. This ability improves students' understanding of mathematical concepts and equips them with essential higher-order thinking skills in the modern era. One approach that is considered effective in improving critical thinking skills is the open-ended approach. This approach encourages students to develop various possible answers, trigger the exploration of ideas, and build logical arguments (Setiawan & Anwar, 2020).

Several previous researchers have studied using the open-ended approach to improve mathematical critical thinking skills. This approach allows students to explore various problem-solving strategies, encouraging them to think more deeply and creatively. Thus, this approach can be an effective strategy in mathematics learning to equip students with essential critical thinking skills in the modern era (Fitriyah et al., 2024).

The open-ended approach in mathematics learning allows students to explore various problem-solving strategies, encouraging them to think more deeply and creatively. By providing problems with more than one correct solution, this approach challenges students to analyze, evaluate, and construct logical arguments, which are core skills in critical thinking.

Several previous studies have discussed the application of the open-ended approach in improving students' mathematical critical thinking skills. For example, research by Amir et

al. (2023) showed that this approach effectively improves the critical thinking skills of junior high school students on quadratic equations. A study by Inayah (2023) also found that the open-ended approach can significantly improve students' mathematical critical thinking skills.

However, despite the extensive research on the open-ended approach, studies still have limitations that integrate this approach with other learning models or in broader contexts. Therefore, further research is needed to explore combining open-ended approaches with other learning strategies to optimize students' critical thinking skills development.

This research is important to identify the development of the application of open-ended approaches in improving critical thinking skills. This study uses bibliometric analysis with a descriptive approach to map publication trends, reveal frequently studied topics, and analyze collaboration patterns among researchers from 2019 to 2024. Data were obtained through Google Scholar, collected using the Publish or Perish application, and then analyzed using VOSviewer software. Thus, this study aims to describe and understand the extent of the development of open-ended approaches in supporting and improving critical thinking skills..

II. METHOD

This study uses bibliometric analysis to explore the application of the *open-ended* approach in improving students' critical thinking skills. This approach is analyzed through various scientific publications to obtain a comprehensive overview of the development, trends, and scientific contributions made by researchers. Each step in the analysis process is carried out systematically to ensure the results are accurate and can be used as a basis for further education research. In this study, several stages of the method were used, namely:

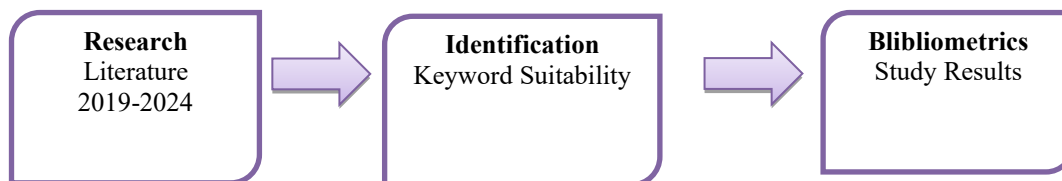


Figure 1. Stages of Literature Review

Based on Figure 1, data was collected through various scientific databases such as *Google Scholar* using appropriate keywords. The literature analyzed was selected based on specific inclusion criteria to ensure relevance to the research topic.

The process can be accelerated in the research identification and search stage by utilizing keywords through *Harzing's Publish or Perish* application. This application is software designed to facilitate researchers in accessing and analyzing bibliometric data. Using this application, researchers can search various scientific sources such as articles, books, and others and evaluate their impact and relevance through metrics such as the number of citations and indexes. In addition, *Publish or Perish* is also helpful for identifying research trends, finding potential collaboration partners, and determining appropriate journals for publication (Jasmadi et al., 2024). An illustration of the use of this application in a literature review can be seen in the following figure.

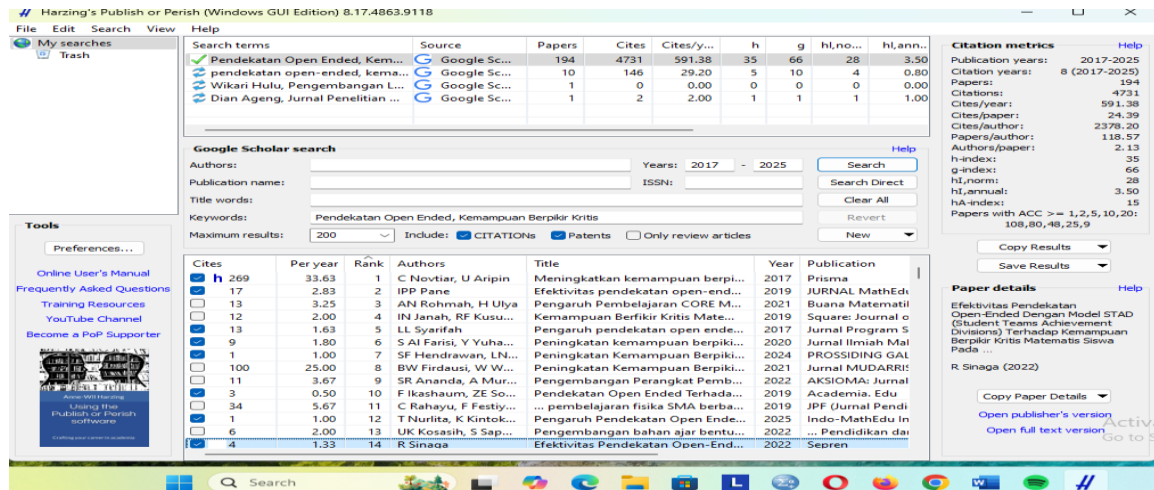


Figure 2. Literature Review through the Harzing's Publish or Perish Application

The next step is identifying the database, as shown in Figure 2, and selecting scientific articles based on several criteria. These criteria include articles that have undergone a thorough peer-review process and been published in national and international journals, the research methods used, the clarity of information presentation, and the relevance of the research to an open-ended approach to improving critical thinking skills.

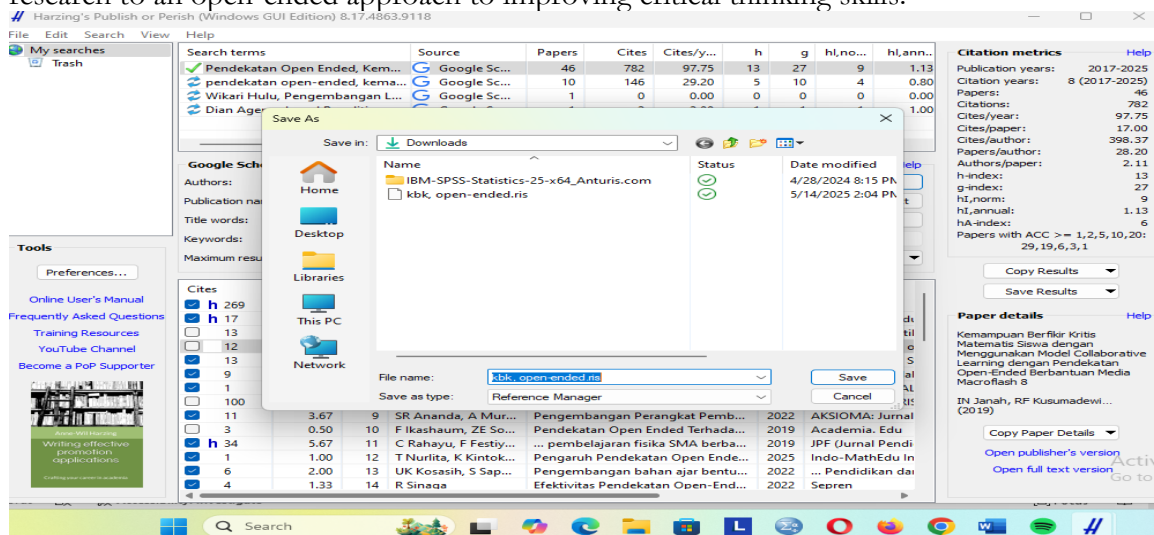


Figure 3. Exporting Files in RIS/Reference Manager Format

Figure 3 shows all relevant journal publications exported in *RIS/Reference Manager* format with text containing keywords. After that, the files are exported to *VOSviewer* for further analysis.

The next stage of data analysis was carried out with the help of software such as *VOSviewer*, which maps the relationships between authors, the frequency of keyword appearances, and the distribution of publications based on time and source. This field is part of information science and library studies aimed at identifying and evaluating patterns in scientific publications, such as author productivity, collaboration among researchers, and the contribution of publications to the development of science. Some techniques used in this analysis include citation analysis, co-citation, and collaborative networks.

III. RESULT AND DISCUSSION

1. Result

This study focused on developing publication trends related to the *open-ended* approach to critical thinking skills, exploring frequently used topics, and identifying collaboration patterns among researchers. The bibliometric analysis in this study initially examined 200 documents. However, only 15 documents related to the keywords "open-ended approach" and "critical thinking skills" were indexed using *Harzing's Publish or Perish* application with publications from 2019 to 2024.

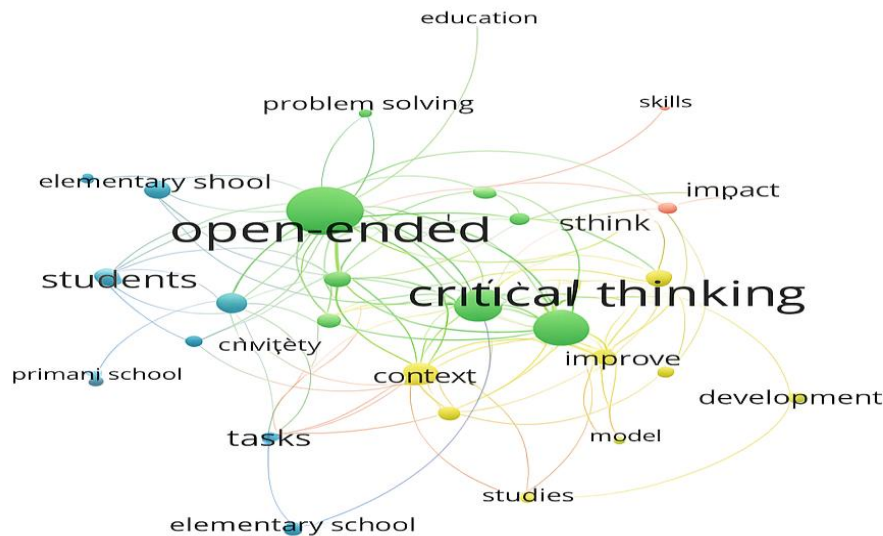


Figure 4. VOSViewer Network Visualization

The bibliometric map visualization above illustrates the connections between keywords frequently appearing in the literature related to the open-ended approach and critical thinking skills. The colors on the map indicate three main clusters formed based on the co-occurrence of keywords. The blue cluster reflects the dominance of research in the field of mathematics education, marked by the appearance of keywords such as "open-ended problem," "mathematics education," and "problem-solving." The green cluster highlights the integration of the open-ended approach in the context of science and STEM, with keywords such as "STEM education," "science learning," and "inquiry." Meanwhile, the red cluster focuses on the theme of evaluation and assessment, marked by the appearance of the keywords "critical thinking skills," "assessment," and "AKM." The size of the nodes (circles) indicates the frequency of keyword appearance, with words such as "critical thinking" and "open-ended" having the largest node size, indicating that they are the primary focus of the research.

The connecting lines between nodes indicate close thematic relationships, for example, between "higher-order thinking" and 'mathematics' and "STEM," which shows the contextual relevance of applying "open-ended" in promoting higher-order thinking. Color density also indicates the intensity of the study; brighter areas indicate areas that have been studied more extensively. This visualization provides an overall picture of the research landscape and opportunities for future topic development.

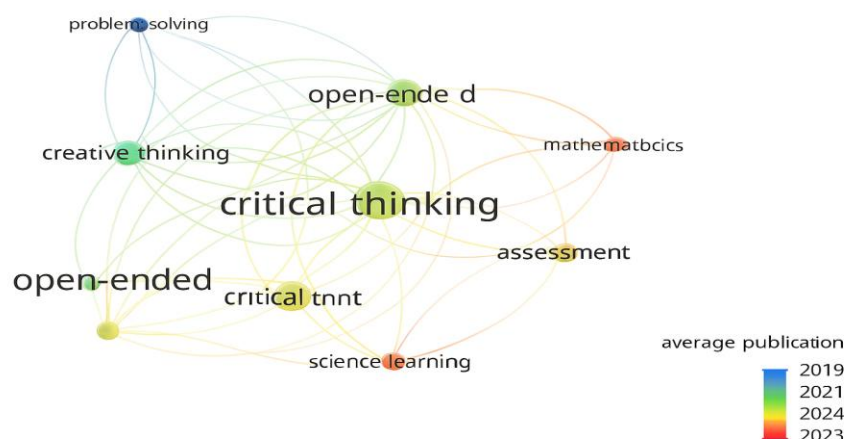


Figure 5. VOSViewer Overlay Visualization

The overlay visualization above shows the distribution of keyword occurrences in the analyzed articles based on the average year of publication. The color of each node indicates the dominant year of publication: blue indicates keywords that frequently appear in older articles (around 2019–2020), while yellow to red indicates keywords that frequently appear in recent publications (2023–2024).

The visualization shows that the words "problem-solving" and "creative thinking" are themes that have been studied for quite some time, as indicated by their blue and green colors. Conversely, the words "assessment," "science learning," and "critical thinking" appear in yellow to red, indicating that these topics have begun to receive more attention in recent years.

Interestingly, the words "open-ended" and "critical thinking" appear as central nodes with many connections to other keywords and are colored yellowish green, indicating that both remain relevant throughout the year and even experience an increase in intensity in recent years. This indicates that studies on strengthening critical thinking through an open-ended approach continue to develop and are a significant concern in contemporary education.

The increasing attention to the *open-ended* approach from year to year shows a growing awareness of the importance of exploration and reflection-based learning. Research by Hidayat et al. (2020) and Setiawan Anwar (2020) confirms that students involved in *open-ended* learning are better able to produce various alternative solutions, deepen their arguments, and are more courageous in expressing their opinions.

The interconnection of clusters in the bibliometric map also indicates the emergence of collaboration between researchers across fields such as mathematics, science, and educational technology. However, there are still gaps in implementation at the policy and assessment levels, particularly in the context of AKM question development, which does not fully reflect the principles of open-endedness.

2. Discussion

The bibliometric results revealed that the open-ended approach is a significant concern in educational research on developing critical thinking skills. However, rather than stopping at keyword mapping or frequency of term occurrence, it is important to understand why this approach continues to evolve and what its implications and challenges are for the future.

First, the development of research on the open-ended approach reflects a paradigm shift in education from answer-oriented learning to learning that emphasizes thinking processes, exploration, and argumentation. This aligns with the current global demand for graduates who can think critically, creatively, and flexibly when facing complex issues. In this context, the open-ended approach allows students to develop diverse problem-solving strategies and build a deeper understanding of academic concepts.

Second, although this approach is theoretically ideal, its practical implementation is not always easy. Teachers need to be prepared to develop appropriate questions and learning scenarios. Teachers must also be able to provide appropriate scaffolding so that students do not feel confused when faced with open-ended problems. Unfortunately, many teachers are still unfamiliar with or lack adequate training to use this approach effectively. This gap needs to be bridged through teacher training and professional development programs.

Third, bibliometric analysis also shows that research focus is still dominant in mathematics and science. However, critical thinking skills are also important in social studies, language, and the arts. Thus, more studies exploring the open-ended approach across subjects are needed so that this approach is not considered exclusive to the exact sciences.

Furthermore, the emergence of keywords such as "assessment" and "AKM" (Minimum Competency Assessment) in the discussion cluster indicates that open-ended approaches are beginning to be considered in the context of learning evaluation. This is an important step towards a more authentic and holistic assessment. However, the challenge is developing assessment instruments that can capture the diversity of student responses fairly and objectively without simplifying their thinking processes into mere numerical scores.

Finally, the collaboration between researchers emerging in network visualization shows positive potential for developing this approach. Cross-disciplinary, cross-institutional, and even cross-national collaboration can enrich the open-ended approach regarding design, theory, and application context. However, this collaboration needs to be encouraged in a more structured manner, for example, through joint research projects, open academic forums, or collaborative publications.

Considering these various aspects, it is clear that the open-ended approach is not just a passing trend in educational research but a response to the demands of the times. The synergy between theory and practice, research, and educational policy is needed for its benefits to be widely felt. This approach must be continuously reviewed, refined, and disseminated to become integral to 21st-century learning systems.

IV. CONCLUSION

Based on a bibliometric analysis of 15 scientific articles published between 2019 and 2024, it can be concluded that the application of open-ended approaches to improve critical thinking skills is a growing topic and a serious concern in the world of education, particularly in mathematics, science, and competency-based assessment. Bibliometric visualization shows that this topic forms three main interconnected clusters, with critical thinking and open-ended as dominant nodes that have strong connections with other concepts such as problem solving, STEM, and assessment. In addition, the publication year overlay map shows a shift in focus toward the development of assessment instruments and the integration of open-ended-based curricula in recent years. This indicates that, in addition to being an effective learning approach, open-ended tasks also hold great potential as a foundation for learning evaluation that can measure higher-order thinking skills in a more authentic and comprehensive manner.

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