Critical Thinking Skills on Physics Learning: A Bibliometric Analysis using Publish or Perish and VOS Viewer

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Abstract. In the 21st century, students are expected to have the ability to problem-solve, be creative, innovative, communicative, and collaborative. Students with critical thinking skills are expected not only to become more critical individuals themselves but also to be able to transform their way of life and perspective in their daily lives. This research is a bibliometric analysis conducted using the Publish or Perish and VOS Viewer software in an effort to understand the research trends related to critical thinking skills, with metadata sourced from Scopus and Google Scholar from 2019 to 2023. Based on this research, it is known that the research trend related to critical thinking skills is undergoing a shift, and future opportunities are related to assessment and e-learning. It can be concluded that this research has been widely conducted, and it is hoped that future researchers can follow trends that have potential opportunities.

Keywords: Critical Thinking, Bibliometric Analysis, Physics Learning, VOS Viewer

1 Introduction

Physics learning in schools is the process of teaching and learning that focuses on understanding the principles and phenomena of physics [1–3]. Typically, physics education in schools begins from the middle school level to the high school level. The main objective of physics education is to develop students' understanding of the fundamentals of physics and prepare them to apply these concepts in everyday life and other fields of science [4, 5]. Physics education usually involves a combination of theory, experimentation, and problem-solving [6, 7]. During physics education in schools, it is important for teachers to encourage active student participation, critical thinking, and collaboration. Physics education in schools should also consider relevance to the real world. Teachers should be able to connect physics concepts with their applications in everyday life [8–10].

Physics learning can encourage students to develop higher-order thinking skills in various ways [11, 12]. One of the higher-order thinking skills developed in physics

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learning is critical thinking skills. Critical thinking skills play a significant role in physics learning. Critical thinking involves the ability to analyze, evaluate, and connect information in a logical and rational manner [13, 14]. In the context of physics, critical thinking helps students understand complex concepts, develop a deep understanding of physics principles, and apply that knowledge to problem-solving [15, 16].

In physics learning, it is important to encourage and develop students' critical thinking skills through various teaching methods. Teachers can provide questions that stimulate critical thinking, encourage group discussions, present complex problems, and provide opportunities for independent thinking. By developing critical thinking skills, students will gain a deeper understanding of physics and be able to apply their knowledge more effectively in various contexts [17, 18].

Critical thinking abilities let students examine data, make arguments and provide evidence, think critically by putting forth ideas, look into phenomena to substantiate their findings, and learn new material. A number of factors, including learning styles, how learning is implemented, conceptual understanding, and problem-solving abilities, affect how well students use their critical thinking abilities [19–21]. Thus, it may be said that critical thinking abilities are deep thinking abilities that probe and confront any form of tight gaps in current issues, producing precise new ideas.

Based on the facts presented in this study, it certainly attracts the attention of researchers due to its fundamental urgency in improving the expected learning outcomes [22, 23]. However, critical thinking skills in physics are not a newly studied topic. In the past five years alone, there have been many articles or documents on this topic. In essence, bibliometric analysis has the principle that a research should be connected or related to other research [24]. Thus, to understand the research trends related to critical thinking skills and explore the possibilities for further research in this topic, bibliometric analysis can be used. Bibliometric analysis is a valuable statistical tool for mapping the state of scientific knowledge, as it helps identify important information needed. The use of bibliometric analysis in this research is expected to identify trends in a particular research area, allowing researchers to connect their research findings to other studies. As expected in research, its role is to create progress and develop knowledge in a specific field. Specifically, the purpose of this research is to understand the development of literature on "critical thinking skills".

2 Method

This study used a data collection method through literature research by applying bibliometric analysis methods. Bibliometrics is a methodology that uses statistical and mathematical techniques to analyze and assess scientific article literature. In order to obtain secondary data from earlier journal articles and conference papers from the Scopus and Google Scholar databases using title and keyword searches, the data collecting method known as "Publish or Perish" (PoP) was carried out in March 2023. The data search using the title "Critical Thinking Ability in Physics" with the keyword "physics" and the title "Critical Thinking Ability" with the keyword "physics" resulted in 47 metadata, including journal articles, previous articles, and theses.

The metadata results were copied to Microsoft Excel and selected with the limitation to journal articles and previous articles, and then continued with the research topics and objectives. Then, they were exported in RIS (Research Information System) format. After that, the data was visualized in VOS viewer based on "title and abstract" to map the research variables using a total item count method with a minimum item similarity set at 2. From the 98 items, 506 relationships between articles were obtained. The visualization results were mapped into 12 clusters, forming a network. Next, the selected results were sorted and analyzed within the visualization clusters of various research topics. Then, each research topic was explained by reviewing each collected literature.

3 Results and Discussion

Based on the relationship and similarity of words in the title and abstract using the method of calculating the overall count, generate a visualization of the bibliometric analysis results as shown in Figure 1.

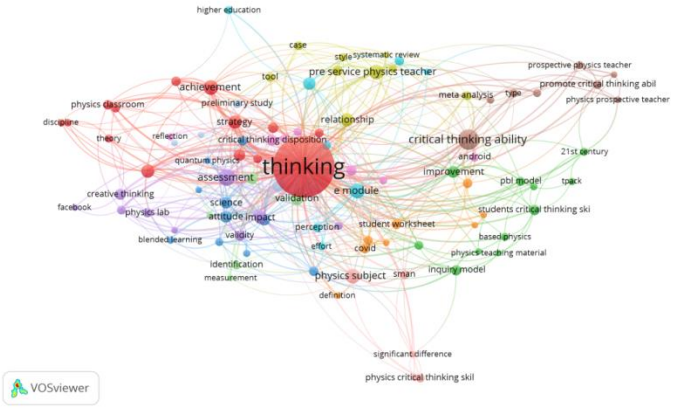

Fig. 1. Network Visualization of the critical thinking in physics learning.

Sorting the items according to the re-search subject in Table 1 creates 12 groups of mapping results, which are then arranged based on the visualization in Figure 1.

Table 1. Cluster mapping results

Cluster	Colour	Topics
1	Red	Thinking, critical thinking test, physics classroom, leraning strategy
2	Green	Physics teaching material, student critical thinking, 21st century, TPACK, PBL model
3	Blue	Quantun physics, science, direct instruction, conceptual understanding
4	Yellow	Meta-analysis, systematic review, pre service teacher,
5	Purple	Assesment, creative thinking, physics lab, impact

6	Light Blue	Physics, e-module, higher education, blended learning
7	Orange	Inquiry learning model, scientific approach, senior high school physics, pandemic, covid
8	Brown	Critical thinking ability, prospective physics teacher, pre-service physics teacher
9	Pink	Physics teaching, critical thinking disposition, android
10	Magenta	Physics subject, physics critical thinking
11	Light Green	Critical thinking test, measurement, validation
12	Light Purple	Physics concept, elearning, paper

Based on the items in the cluster, it can be mapped into topics such as critical thinking analysis, critical thinking skills assessment instruments, learning to improve critical-thinking skills, critical thinking skills assessment indicator, research subject, and physics theory.

3.1 Critical Thinking Analysis

In terms of the analysis of critical thinking skills in physics, several research findings regarding the level of critical thinking skills in physics are as follows:

Table 2. Result of the analysis of critical thinking skills in physics.

Author	Analysis Result
[25], [26]	Students still do not possess all aspects of critical thinking skills, having a high ability in the identification aspect but low in the evaluation aspect. However, in the research findings of Susilawati et al. (2020), the lowest level of critical thinking skills is found in the analysis aspect.
[27]	The critical thinking skills of students in physics are still low.
[28]	The level of critical thinking skills in the category of Reasoning is very high, while in the category of Argument Analysis, it is very low.
[23]	The highest indicator of critical thinking skills is considering the credibility of sources, while the lowest is making action decisions.

3.2 Critical Thinking Skills Assessment Instruments

Assessment instruments to measure critical thinking skills have been developed with various forms of tests. The details are as follows:

Table 3. Critical Thinking Skills Assessment Instruments Form

Author	Analysis Result
[29]	Critical Thinking Test
[30],[31],[32]	Four Tier Diagnostic Test
[33]	Complex Multiple Choice
[34],[35]	Three-Tier Diagnostic Test
[36],[37]	Essay
[38],[39]	Open-Ended

Based on Table 3, assessment instruments for measuring critical thinking skills are often developed in the form of essay and multiple-choice tests because they are more

comprehensive in assessing critical thinking skills in physics. In these test instrument, students are given the opportunity to express their understanding of physics concepts, analysis, and reasoning in response to open-ended questions [40, 41].

3.3 Learning To Improve Critical-Thinking Skills

Based on Table 2, it is known that the analysis of critical thinking skills in physics is still low in most aspects of critical thinking skill indicators. However, various efforts have been made to improve critical thinking skills by implementing models and learning strategies to enhance critical thinking abilities. Several efforts have been implemented, such as problem-based learning, project-based learning, and direct instruction. More details are presented in Table 4 below.

Table 4. Critical Thinking Skills Assessment Instruments Form

Author	Innovative Learning	Result
[42]	Problem-based hybrid learning model	The teaching with Pro-BHL model can enhance the students' cts
[22]	Inquiry-discovery	Teachers empower HOTS ability of the students in the inquiry-discovery class, so that a meaningful learning and student-centered learning can be created.
[43]	CinQASE learning model	The learning with the CinQSE model received positive responses, and furthermore, this learning model is effective in enhancing critical thinking skills
[44]	Guided inquiry learning model	The result of this research is that learning model of guided inquiry effective to improve students' critical thinking skills.

Many learning innovations have been implemented to improve the quality of students' critical thinking skills in physics. The results have mostly been successful in enhancing critical thinking abilities. However, several factors also contribute to the incompatibility of these learning models in other contexts. In essence, collaborative learning that involves student participation is one of the effective approaches [45].

3.4 Research Subject

Research on critical thinking skills has been conducted at various levels of education, ranging from elementary schools, junior high schools, senior high schools, and even universities. The target of the research is not only limited to students and first-year university students but also extends to prospective physics teachers. The distribution of research subjects on critical thinking skills is presented in the following Table 5.

Table 5. Research Subject Critical Thinking Skills

Author	Analysis Result
[46]	Elementary school students
[47]	Junior high school students
[43],[42],[44]	Senior high school students

[48]	Student College
[49]	Prospective physics teacher students

4 Conclusion

Based on the results of research and discussion indicate that critical thinking skills are essential for students in learning physics. The measurement of critical thinking skills is conducted through various forms of tests developed by researchers. The analysis of critical thinking skills also reveals a low level of proficiency. However, there have been significant improvements through the implementation of collaborative learning. There are still ample opportunities for further research on critical thinking skills, particularly regarding instructional media, adaptive testing, and the development of teaching models.

References

1. Maknun, J.: Implementation of Guided Inquiry Learning Model to Improve Understanding Physics Concepts and Critical Thinking Skill of Vocational High School Students. Int. Educ. Stud. 13, 117–130 (2020).
2. Faridi, H., Tuli, N., Mantri, A., Singh, G., Gargrish, S.: A framework utilizing augmented reality to improve critical thinking ability and learning gain of the students in Physics. Comput. Appl. Eng. Educ. 29, 258–273 (2021).
3. Retnawati, H., Arlinwibowo, J., Wulandari, N.F., Pradani, R.G.: Teachers' difficulties and strategies in physics teaching and learning that applying mathematics. J. Balt. Sci. Educ. 17, 120 (2018).
4. Rifandi, R., Rahmi, Y.L.: STEM education to fulfil the 21st century demand: a literature review. In: Journal of Physics: Conference Series. p. 12208. IOP Publishing (2019).
5. Ince, E.: An Overview of Problem Solving Studies in Physics Education. J. Educ. Learn. 7, 191–200 (2018).
6. Bancong, H., Song, J.: Exploring how students construct collaborative thought experiments during physics problem-solving activities. Sci. Educ. 29, 617–645 (2020).
7. Rokhmat, J., Putrie, S.D.: A strategy of scaffolding development to increase students' problem-solving abilities: The case of physics learning with causalitic-thinking approach. J. Turkish Sci. Educ. 16, 569–579 (2019).
8. Satriawan, M., Rosmiati, R., Widia, W., Sarnita, F., Suswati, L., Subhan, M., Fatimah, F.: Physics learning based contextual problems to enhance students' creative thinking skills in fluid topic. In: Journal of Physics: Conference Series. p. 22036. IOP Publishing (2020).
9. Wang, Q., Su, M.: A preliminary assessment of the impact of COVID-19 on environment–A case study of China. Sci. Total Environ. 138915 (2020).
10. Sastradika, D.: Development of subject-specific pedagogy based on guided inquiry about newton's law to improve senior high school students' scientific literacy ability. In: Journal of Physics: Conference Series. p. 12017. IOP Publishing (2018).
11. Astutik, S., Bektiarso, S., Lesmono, A.D., Nuraini, L.: What can students show about higher order thinking skills in physics learning? In: IOP Conference Series: Earth and Environmental Science. p. 12127. IOP Publishing (2019).

12. Suprapto, E., Sumiharsono, R., Ramadhan, S.: The Analysis of Instrument Quality to Measure the Students' Higher Order Thinking Skill in Physics Learning. J. Turkish Sci. Educ. 17, 520–527 (2020).
13. Fahmi, F., Setiadi, I., Elmawati, D., Sunardi, S.: Discovery learning method for training critical thinking skills of students. Eur. J. Educ. Stud. (2019).
14. Din, M.: Evaluating university students' critical thinking ability as reflected in their critical reading skill: A study at bachelor level in Pakistan. Think. Ski. Creat. 35, 100627 (2020).
15. Rahman, M.: 21st century skill'problem solving': Defining the concept. Asian J. Interdiscip. Res. 2, 64–74 (2019).
16. Hafni, R.N., Herman, T., Nurlaelah, E., Mustikasari, L.: The importance of science, technology, engineering, and mathematics (STEM) education to enhance students' critical thinking skill in facing the industry 4.0. In: Journal of Physics: Conference Series. p. 42040. IOP Publishing (2020).
17. Bao, L., Koenig, K.: Physics education research for 21st century learning. Discip. Interdiscip. Sci. Educ. Res. 1, 1–12 (2019).
18. Tiruneh, D.T., De Cock, M., Weldeslassie, A.G., Elen, J., Janssen, R.: Measuring critical thinking in physics: Development and validation of a critical thinking test in electricity and magnetism. Int. J. Sci. Math. Educ. 15, 663–682 (2017).
19. Hadi, S.A., Susantini, E., Agustini, R.: Training of students' critical thinking skills through the implementation of a modified free inquiry model. In: Journal of Physics: Conference Series. p. 12063. IOP Publishing (2018).
20. McDonald, S.D.: Enhanced Critical Thinking Skills through Problem-Solving Games in Secondary Schools. Interdiscip. J. E-Learning Learn. Objects. 13, (2017).
21. Andrini, V.S.: The Effectiveness of Inquiry Learning Method to Enhance Students' Learning Outcome: A Theoritical and Empirical Review. J. Educ. Pract. 7, 38–42 (2016).
22. Hudha, M.N., Batlolona, J.R.: How are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theorethical overview? Eurasia J. Math. Sci. Technol. Educ. 14, 691–697 (2017).
23. Perdana, F.A., Sarwanto, S., Sukarmin, S., Sujadi, I.: Development of e-module combining science process skills and dynamics motion material to increasing critical thinking skills and improve student learning motivation senior high school. In: International Journal of Science and Applied Science: Conference Series. pp. 45–54 (2017).
24. Agarwal, A., Durairajanayagam, D., Tatagari, S., Esteves, S.C., Harlev, A., Henkel, R., Roychoudhury, S., Homa, S., Puchalt, N.G., Ramasamy, R.: Bibliometrics: tracking research impact by selecting the appropriate metrics. Asian J. Androl. 18, 296 (2016).
25. Merta Dhewa, K., Rosidin, U., Abdurrahman, A., Suyatna, A.: The development of Higher Order Thinking Skill (Hots) instrument assessment in physics study. IOSR J. Res. Method Educ. 7, 26–32 (2017).
26. Umam, K., Susandi, A.D.: Critical Thinking Skills: Error Identifications on Students' with APOS Theory. Int. J. Eval. Res. Educ. 11, 182–192 (2022).
27. Asysyifa, D.S., WİLUJENG, İ., Kuswanto, H.: Analysis of students critical thinking skills using partial credit models (Pcm) in physics learning. Int. J. Educ. Res. Rev. 4, 245–253 (2019).
28. Undang Rosidin, U.R., Nina Kadaritna, N.K., Hasnunidah, N.: Can Argument-Driven Inquiry Models Have Impact On Critical Thinking Skills For Students With Different Personality Types? Cakrawala Pendidik. 38, 511–526 (2019).
29. Fuad, N.M., Zubaidah, S., Mahanal, S., Suarsini, E.: Improving junior high schools' critical thinking skills based on test three different models of learning. Int. J. Instr. 10, 101–116 (2017). https://doi.org/10.12973/iji.2017.1017a.

30. Waluyo, A.A.: Critical thinking skills assessment instrument in physics subjects: how to develop a four tier diagnostic test? In: Journal of Physics: Conference Series. p. 22011. IOP Publishing (2021).
31. Ni'mah, Z., Fariyani, Q., Sudarmanto, A.: Four-Tier Multiple Choice Test Characterized by Local Wisdom Values for Analyzing Critical Thinking Skills. Thabiea J. Nat. Sci. Teach. 4, 97 (2021). https://doi.org/10.21043/thabiea.v4i1.8062.
32. Tumanggor, A.M.R., Supahar, Kuswanto, H., Ringo, E.S.: Using four-tier diagnostic test instruments to detect physics teacher candidates' misconceptions: Case of mechanical wave concepts. In: Journal of Physics: Conference Series (2020). https://doi.org/10.1088/1742-6596/1440/1/012059.
33. Tractenberg, R.E., Gushta, M.M., Mulroney, S.E., Weissinger, P.A.: Multiple choice questions can be designed or revised to challenge learners' critical thinking. Adv. Heal. Sci. Educ. 18, 945–961 (2013).
34. Wahyudi, A., Richardo, R.: Development of Three Tier Open-Ended Instrument to Measure Chemistry Students ' Critical Thinking Disposition Using Rasch Analysis. Int. J. Instr. 16, 191–204 (2023).
35. Laeli, C.M.H.: Development of Three Tier Multiple Choice Diagnostic Test to Identify Misconception and Improve Critical Thinking Skill in Science Learning. Ilkogr. Online. 20, (2021).
36. Zubaidah, S., Mahanal, S., Fauzi, A.: Critical Thinking Embedded Essay Test. In: International Conference on Biology, Sciences and Education (ICoBioSE 2019). pp. 171–177. Atlantis Press (2020).
37. Yusar, T.R., Kurniawati, D.: Analysis of students critical thinking skills using essay tests on topics of rate reaction. J. Pijar Mipa. 18, 13–19 (2023).
38. Fajari, L.E.W.: Open-Ended Questions to Assess Critical-Thinking Skills in Indonesian Elementary School. Int. J. Instr. 14, 615–630 (2021).
39. Monrat, N., Phaksunchai, M., Chonchaiya, R.: Developing Students' Mathematical Critical Thinking Skills Using Open-Ended Questions and Activities Based on Student Learning Preferences. Educ. Res. Int. 2022, (2022). https://doi.org/10.1155/2022/3300363.
40. Sunarti, T., Wasis, W., Setyarsih, W., Zainudin, A., Jauhariyah, M.N.R.: Analysis of the Development of Critical Thinking Instruments Test in Physics. In: International Joint Conference on Science and Engineering 2021 (IJCSE 2021). pp. 627–634. Atlantis Press (2021).
41. Mabruroh, F., Suhandi, A.: Construction of critical thinking skills test instrument related the concept on sound wave. In: Journal of Physics: Conference Series. p. 12056. IOP Publishing (2017).
42. Sujanem, R., Poedjiastuti, S., Jatmiko, B.: The Effectiveness of problem-based hybrid learning model in physics teaching to enhance critical thinking of the students of SMAN. In: Journal of Physics: Conference Series (2018). https://doi.org/10.1088/1742-6596/1040/1/012040.
43. Hunaidah, H., Susantini, E., Wasis, W., Prahani, B.K., Mahdiannur, M.A.: Improving Collaborative Critical Thinking Skills of Physics Education Students through Implementation of CinQASE Learning Model. In: Journal of Physics: Conference Series (2018). https://doi.org/10.1088/1742-6596/1108/1/012101.
44. Nisa, E.K., Koestiari, T., Habibbulloh, M., Jatmiko, B.: Effectiveness of guided inquiry learning model to improve students' critical thinking skills at senior high school. In: Journal of Physics: Conference Series (2018). https://doi.org/10.1088/1742-6596/997/1/012049.

45. Warsah, I., Morganna, R., Uyun, M., Hamengkubuwono, H., Afandi, M.: The Impact of Collaborative Learning on Learners' Critical Thinking Skills. Int. J. Instr. 14, 443–460 (2021). https://doi.org/10.29333/iji.2021.14225a.
46. Elfrida Yanty Siregar, Y., Rachmadtullah, R., Pohan, N., Rasmitadila, Zulela, M.S.: The impacts of science, technology, engineering, and mathematics (STEM) on critical thinking in elementary school. In: Journal of Physics: Conference Series (2019). https://doi.org/10.1088/1742-6596/1175/1/012156.
47. Pratama, M.A.R., Cahyono, E., Aggraito, Y.U.: Implementation of Problem Based Learning Model to Measure Communication Skills and Critical Thinking Skills of Junior High School Students. J. Innov. Sci. Educ. 8, 324–331 (2019).
48. Walsh, C., Quinn, K.N., Wieman, C., Holmes, N.G.: Quantifying critical thinking: Development and validation of the physics lab inventory of critical thinking. Phys. Rev. Phys. Educ. Res. 15, 10135 (2019). https://doi.org/10.1103/physrevphyseducres.15.010135.
49. Negoro, R.A., Rusilowati, A., Aji, M.P., Jaafar, R.: Critical Thinking in Physics: Momentum Critical Thinking Test for Pre-service Teacher. J. Ilm. Pendidik. Fis. Al-Biruni. 9, 73–86 (2020). https://doi.org/10.24042/jipfalbiruni.v9i1.4834.

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