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Research Trends on Critical Thinking Skills Based on the Scopus Database

Indah Wulandari [1], Juliyanto [3], Faiz Hasyim [3], dan Setyo Admoko [1,*]
[1] Physics Education, Universitas Negeri Surabaya, Surabaya, Indonesia
[2] Primary Teacher Education, Universitas Negeri Surabaya, Surabaya, Indonesia
[3] Physics Education, STKIP Al Hikmah Surabaya, Surabaya, Indonesia
[*] Email: setyoadmoko@unesa.ac.id

Abstract

Critical thinking is the ability to think clearly and reflectively by examining one's own thought processes as well as those of others. It also represents an attitude of questioning phenomena that go beyond personal experience and considering problems from multiple perspectives. Developing critical thinking skills requires continuous efforts to improve the quality of education in facing the demands of the modern era. Therefore, this study was conducted to map and evaluate research on critical thinking through bibliometric analysis. The aim is to analyze publication trends on critical thinking skills from 2012 to 2022, visualize research patterns using VOSviewer software, and identify how researchers, institutions, and countries contribute to this field. From a total of 1,063 documents, Indonesia emerged as the leading contributor with 557 publications, positioning the Indonesian University of Education as the top institution and Zubaidah, S. as the most productive author. The visualization of research trends revealed three major clusters and one minor cluster, which cover: (1) factors influencing critical thinking skills, (2) training processes in critical thinking, (3) critical thinking disposition, (4) research methods on critical thinking, and (5) instruments for assessing critical thinking. The findings of this study are expected to help researchers identify global trends in critical thinking research. Furthermore, the results provide valuable insights for strengthening the development of critical thinking in physics education, particularly in designing learning models that foster problem solving, logical reasoning, and conceptual understanding.

Keywords: *Bibliometrics, Critical Thinking, and VOSViewer*

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INTRODUCTION

Education is an interaction of factors with other factors involved in it to achieve educational goals. The interaction of these factors is carried out in the learning process when the teacher prohibits values, skills, knowledge from students and students receive good teaching. The goal of the educational process is not just the intellectual development of students by providing a lot of knowledge but education must provide understanding, appreciation and understanding (Mulvey, 1984).

The world of education is inseparable from developed countries. The higher the quality of education in a country, the higher the quality of human resources that can advance and make the country proud (Safitri et al., 2021). As said by Harahap and Poerkatja (Ilmi & Rukun, 2020) assert, education is a deliberate effort of parents and is interpreted in being able to bring about a sense of moral responsibility in every action. What is meant by parents here are the child's parents or people who are obliged to educate such as teachers, priests, and a kiai. Education has a positive impact on the younger generation and with state education it can prepare good and good generations. Therefore, educators must have an attitude of tenacity and patience in teaching in class.

The 21st century requires Human Resources (HR) to have 3 important abilities, namely the ability to think critically, think creatively and solve problems. We usually know these three abilities as higher order thinking skills or HOTS (Higher Order Thinking Skills) (Saraswati & Agustika, 2020). This ability is in order to face the challenges of the 21st century, because in solving problems it is necessary to have the ability to think critically and creatively. In the 21st century learning, the rapid development of science and technology will become a new challenge that must be faced by students (Febrianti et al., 2021). Meanwhile (Prasetyo, 2018) defines thinking as, "All mental activity that helps formulate or solve problems, make decisions or fulfill desires to understand: thinking is a search for answers, an achievement of meaning". John Chaffee, director of the center for language and critical thinking (Hamdanah & Surawan, 2022) explains that thinking is "an active, orderly and meaningful process that we use to make sense of the world". Chaffee defines critical thinking as "thinking to investigate systematically the thinking process itself" (Chaffee, 1992). Then added by Elaine B. Johnson, "The point is not only to think deliberately, but also to examine how we and others use evidence and logic" (Johnson, 2002) simply according to Robert Duron, critical thinking can be defined as: the ability to analyze and evaluate information (Duron et al., 2005).

Critical thinking is a process of formulating reasons actively and skillfully from conceptualizing, applying, analyzing, integrating (synthesizing), or evaluating information collected through a process of observation, experience, reflection, reasoning or communication as a basis for determining action (Lestari et al., 2017). John Dewey said that teachers must teach children the right way of thinking at school. Then he defines critical thinking, namely: "Active, persistent, and careful consideration of a belief or any form of knowledge that is received in view of the various reasons that support it and conclude it (Dewey, 1993).

Critical thinking is very important for students to have, because it allows students to be able to solve social, scientific and practical problems effectively. In this era, knowledge and information are not enough to solve problems. To be able to work effectively in the world of work and in everyday life students must be able to solve problems to be able to make the right decisions. In education, higher-order thinking skills need to be trained and improved, and HOTS questions can also be applied in the learning process. So that many countries in their learning in class are not spared by using HOTS (Saraswati & Agustika, 2020).

In Indonesia, the ability to think at a high level is still low (Kemdikbud, 2019). The evidence in this statement is based on the results of a study by international institutions from the Program for International Student Assessment (PISA), in 2018 where Indonesia was ranked 7th from the bottom. More precisely, in the reading category ranked 74th out of 79 countries participating in PISA, for the category of reading, mathematics ability ranked 73th out of 79 participating countries, while in the science category Indonesia was ranked 71st out of 79 countries participating in PISA (Hewi & Shaleh, 2020). Based on this empirical data, the effort that researchers can make in improving the learning process is to abandon classical learning as early as possible and tend to only facilitate student understanding. To strengthen the competitive spirit in this era, an important aspect of skills in responding to challenges in the 21st century is the ability to think critically (Hartini, 2017). By looking at this fact, an assessment of education can be carried out by conducting research by considering and giving meaning as well as meaning to the information that has been collected or comparing the information obtained with previously formulated standards (Nurdyansyah & Fahyuni, 2016).

Many studies have discussed critical thinking skills. Research from (Janah et al., 2019) says that the 21st century learning paradigm emphasizes students' ability to think critically, be able to connect knowledge with the real world, master information and communication technology, and collaborate. The solution to addressing 21st century learning is that students or students are able to think critically and be literate. Research from (Febrianti et al., 2021) concludes that critical thinking skills are used to face the challenges of the 21st century. Critical and creative thinking is needed in solving problems. From this research example, it is very necessary to evaluate research results in order to design a strategic plan for further research. In this activity, data availability and data reliability related to research are needed.

How to maximize the strategic plan for further research by conducting bibliometric analysis. Bibliometric studies are studies in library science that apply statistics and mathematics. Bibliometrics is a way of thoroughly describing scientific journals and other publications, both written and unwritten (Royani & Idhani, 2018).

Bibliometrics cannot be separated from literature or books and is related to measurement. The term comes from the word biblio which means book and metric means measuring (Aulia & Rusli, 2020). Broadly, bibliometrics is used to study how science influences technology, investigate the development of new knowledge in various fields, and obtain mapping from scientific fields (Hufiah et al., 2021). Mapping here is defined in the form of visualizing maps with scientific topics to assist researchers in compiling their research programs. This visualization can be presented using VOSViewer.

Some of the characteristics possessed by VOSViewer include mapping from the type of bibliometric analysis, supporting several large bibliographic databases, using visualization and density overlay features, ignoring the time dimension, intended as a text processing function, limited in analyzing small or medium amount of data, and using layout and cluster techniques. VOSViewer is a computer program developed for building and viewing bibliometric maps.

Database sources that are usually used in bibliometric mapping with VOSViewer are Google Scholar, Crossreff, Scopus, Web of Science, and Microsoft Academic Search (Hufiah et al., 2021). This research will use the Scopus database. Where the meaning of Scopus itself is one owned by a leading publisher to search databases (data centers) of citations / scientific literature (Utami, 2018). Scopus creates a scientific literature index to provide accurate information regarding the metadata of each scientific article including abstracts, publication data, and other references. Scopus helps researchers to track, analyze, and visualize research more effectively (Hakim, 2020).

This study aims to answer questions that focus on research trends on critical thinking skills:

1. What is the output profile of critical thinking skills in the 2012-2022 range?
2. To what extent is the distribution of publications about critical thinking skills across countries and institutions in the world?
3. Who are the TOP authors in researching critical thinking skills?
4. What is the pattern of publications on critical thinking skills in the 2012-2022 period?
5. What are the results of the visualization of research trends regarding critical thinking skills?
6. What is the contribution of Indonesian authors in researching critical thinking skills in the 2012-2022 period?

RESEARCH METHOD

This research is a type of descriptive research using bibliometric methods. Research adapted from research by (Tupan et al., 2018) and (Aribowo E, 2019). Scopus data as the source of this research, with search keywords related to critical thinking skills, namely critical thinking, critical thinking skills. Data collection was carried out using Scopus data because it provides abstracts from various literature to research that has been reviewed and is the largest academic database globally (Tupan et al., 2018).

Research Design

Researchers conducted an online search on May 14, 2022, using the keywords critical thinking skills from 2012 to 2022. The data obtained were document titles, authors, years of publication, sources, and citations. Furthermore, other search results can be downloaded in (.ris) format. Research subjects were analyzed using Microsoft excel. Such as the trend of critical thinking publications and document type charts processed using Microsoft Excel which will later be formed into graphs whose purpose is to make it easier for readers to understand this research. When finished, then analyze the mapping data using the VOSViewer software. The bibliometric research flowchart is as shown in Figure 1.

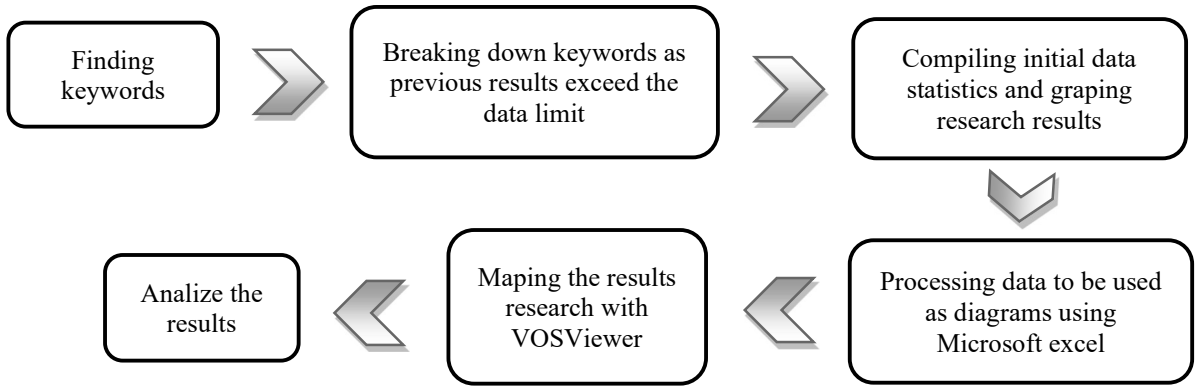

Figure 1. Steps to Conduct Research using Bibliometric Analysis

Research Procedure

A total of 1063 documents met the criteria from 2012 to 2022. Data is documented in word and (.ris) form. The software needed is Microsoft Word, Microsoft Excel and VOSViewer. VOSViewer is used to

determine research trends on critical thinking skills (Suprapto et al., 2011). An illustration of the initial search and refinement of the research can be seen in Figure 2.

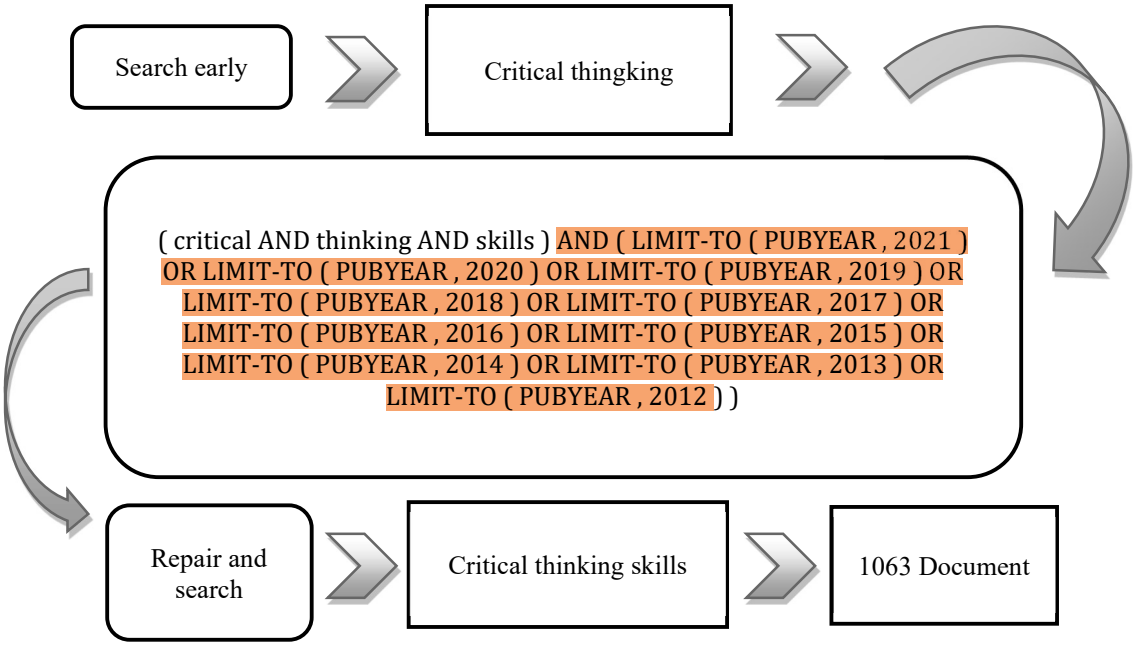

Figure 2. Initial Search and Refinement of Research

RESULTS AND DISCUSSION

Publication Results, Types of Document Sources and Language

The resulting data search contained 1063 documents related to critical thinking skills with the Scopus database. From the search results the number of documents based on the type of source obtained was in the form of Journals, Conference Proceedings, Books, Book Series, and some were not detected. Publications devoted to this research from 2012 to 2022 are shown in Figure 3 and Figure 4. The number of critical thinking documents published throughout the year increased significantly. Since 2012 there have been more than 30 published documents. Even though it had fluctuated in the 2020-2021 period, in the previous years there was a significant increase, especially in 2015-2016 published documents increased from 33 documents to 62 documents. Published documents have increased in 1 decade. And it can be predicted that the number of articles in 2022-2025 will increase.

The number of articles based on sources shows that journals dominate articles with 583 documents, then followed by conference proceedings with 441 documents, books with 27 documents, book series with 11 documents, and finally only 1 document which is not defined.

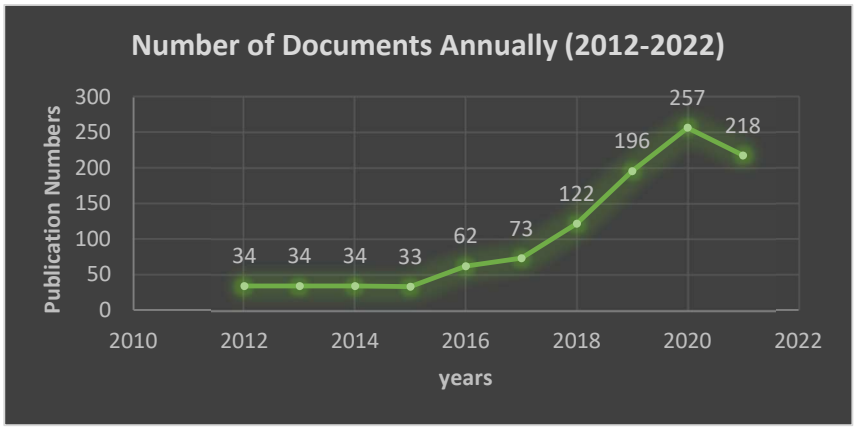

Figure 3. Number of Documents on Critical Thinking Skills in the Last Ten Years (2012-2022)

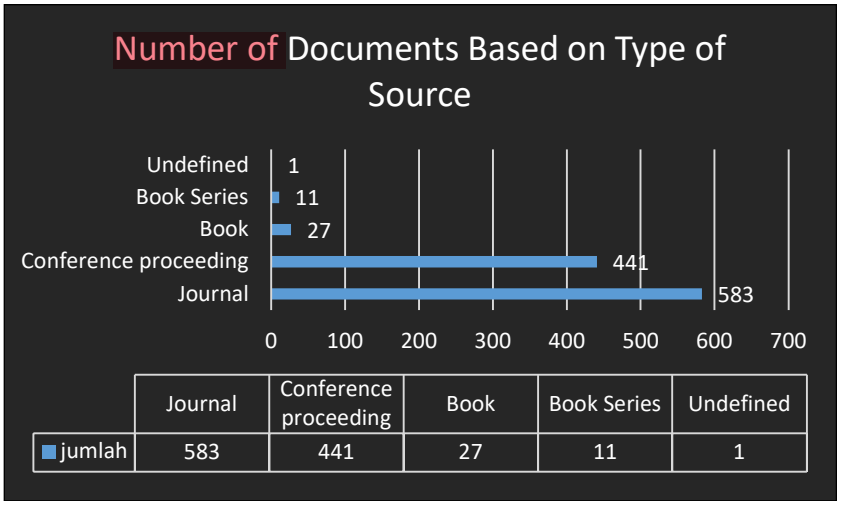

Figure 4. Number of Articles on Critical Thinking Skills by Source Category

Furthermore, out of a total of 1,063 documents found, most were in English as the language of the article (1042 documents or 98%). This data shows that most of the published documents come from the international level because they are used in English. Other documents use Spanish (8 documents or 1%), Turkish (5 documents or 1%), Persian and Portuguese (4 documents or 0%), Arabic (3 documents or 0%), and Dutch, Italian, Korea, and Russia 1 document or 0% each. The number of documents by language can be seen in Figure 5.

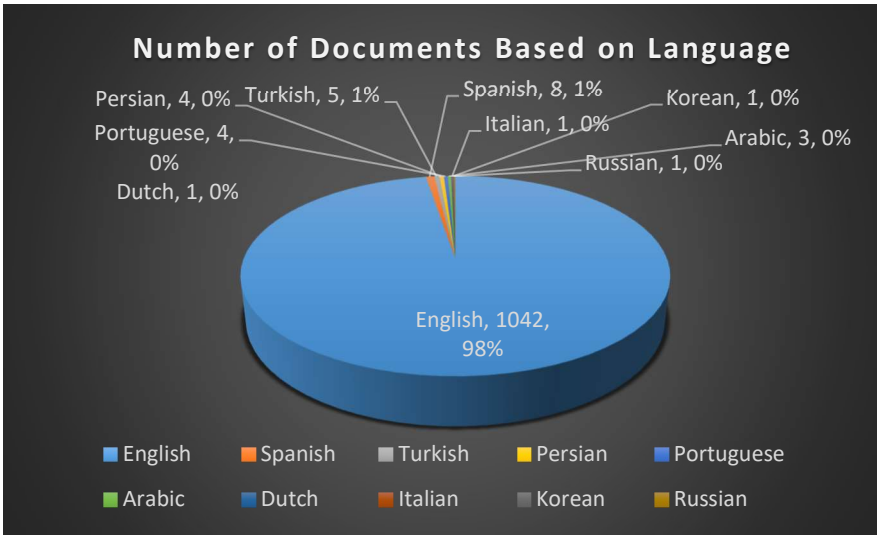

Figure 5. Percentage of Articles on Critical Thinking Skills Based on Language in the Year 2012-2022

Cross-Country Distribution of Publications

From the database obtained for the number of cross-country documents, there are ten countries that have contributed the most to critical thinking research and it can be seen clearly in Figure 6 that articles are dominated by the state of Indonesia with 557 documents from 2012-2022. Other countries that contributed to this topic contributed such as the United States (155 documents), Malaysia (56 documents), Turkey (47 documents), Iran (24 documents), Australia (22 documents), China (18 documents), United Kingdom (17 documents). documents), Japan (16 documents), and Taiwan (15 documents).

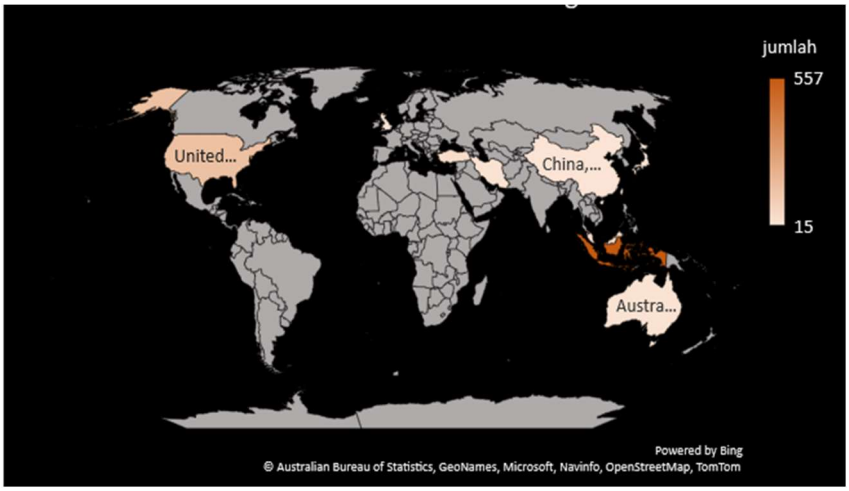

Figure 6. Number of Documents by Country in 2012-2022

Table 1. Number of Documents by Country

Country	Number of Documents
Indonesia	557
Amerika Serikat	155
Malaysia	56
Turki	47
Iran	24
Australia	22
China	18
Britania Raya	17
Japan	16
Taiwan	15

The number of documents on the topic Critical thinking skills in the 2012-2022 range for the top 10 cross-institutional rankings can be seen in table 2 below. Most documents on this topic are dominated by institutions originating from Indonesia. The Indonesian University of Education became the affiliate that contributed the most documents on critical thinking topics, namely 82 documents.

Table 2. Number of research documents on critical thinking skills (2012-2022) across institutions

No	Affiliation	Number of Documents
1	Universitas Pendidikan Indonesia	82
2	Universitas Negeri Malang	74
3	Universitas Sebelas Maret	64
4	Universitas Negeri Yogyakarta	51
5	Universitas Negeri Surabaya	34
6	Universitas Negeri Jakarta	26
7	Universitas Negeri Semarang	23
8	Universitas Jember	21
9	Universitas Lampung	18
10	Universitas Teknologi Malaysia	17

Top Author in Researching the Critical Thinking Ability Research Topic

The most productive writer in research on the topic of critical thinking is shown in Figure 7 and Figure 8.

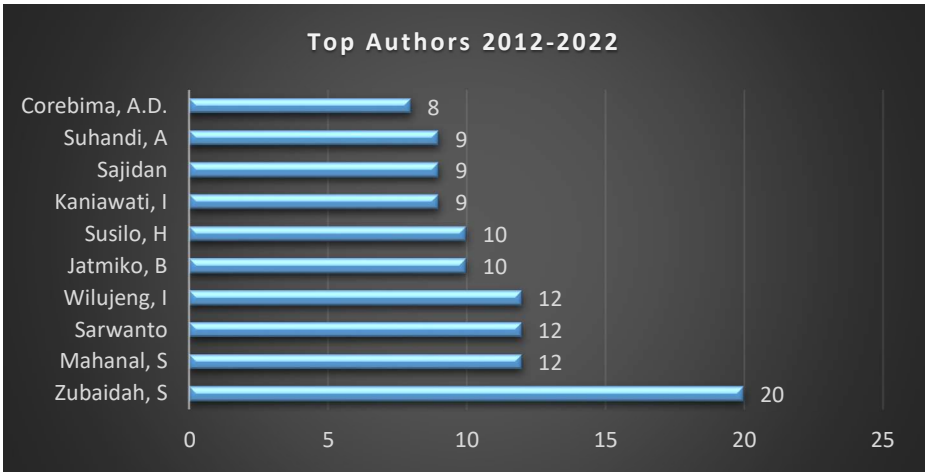

Figure 7. Top Authors in Researching Critical Thinking Skills (2012–2022)

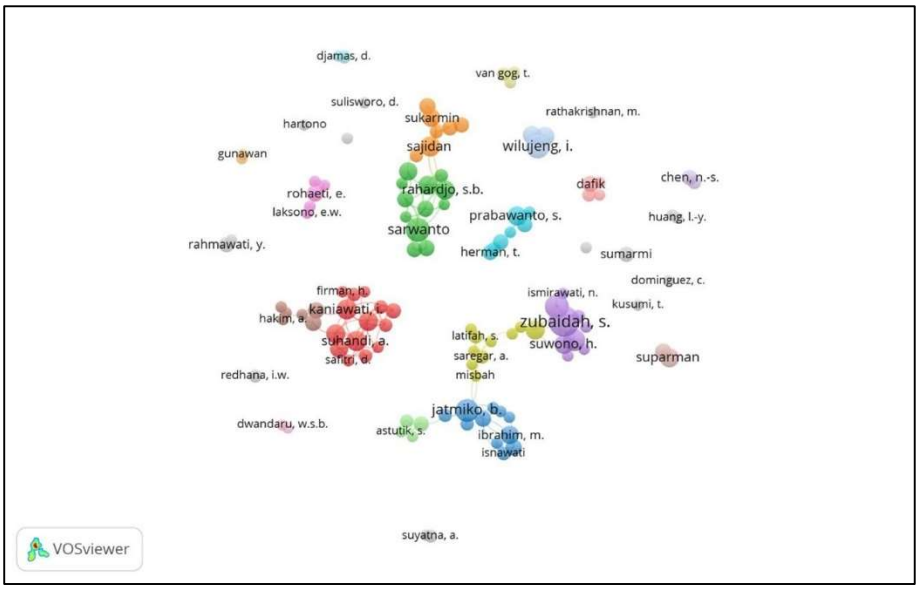

Figure 8. Collaboration Map of Leading Authors in Critical Thinking Research (2012–2022)

The most productive writer on this topic is Zubaidah, S with one of the journal titles namely *Improving junior high schools' critical thinking skills based on the test of three different models of learning* (Fuad et al., 2017). Mahanal, S with one of the article titles is *Revealing the relationship between reading interest and critical thinking skills through REMAP GI and REMAP jigsaw* (Zubaidah et al., 2018). Jatmiko, B. with one of their journal titles, namely *"The Comparison of ORIPA Teaching Model and Problem-Based Learning Model Effectiveness to Improve Critical Thinking Skills of Pre-Service Physics Teachers"* (Jatmiko et al., 2018). Kaniawati, I. with the title *"Analysis of Critical Thinking Skills on the Topic of Static Fluid"* (Puspita et al., 2017). Sajidan with one of his journal titles, *"Improving Students' Critical Thinking Skills in Cell-Metabolism Learning Using Stimulating Higher Order Thinking Skills Model."* (Saputri et al., 2019). Suhandi, A. with one of his article titles, *"Effect of Higher Order Thinking Laboratory on the Improvement of Critical and Creative Thinking Skills"* (Setiawan et al., 2018). Corebima, A. D. with one of his journal titles, *"The Correlation Between Critical and Creative Thinking Skills on Cognitive Learning Results"* (Sıburıan et al., 2019). Top authors in this topic during 2012–2022 can be seen in the Table 3.

Table 3. Table of Top Citations of Articles/Journals for the Year 2012 – 2022

Author	Source	Citations
Kong, S.C. (2014)	Computers and Education 78, pp. 160-173	227
Fuad, N.M., Zubaidah, S., Mahanal, S., Suarsini, E. (2017)	International Journal of Instruction 10(1), pp. 101-116	103
Niu, L., Behar-Horenstein, L.S., Garvan, C.W. (2013)	Educational Research Review 9, pp. 114-128	99
Duran, M., Dökme, I. (2016)	Eurasia Journal of Mathematics, Science and Technology Education 12(12), pp. 2887-2908	95
Flores, K.L., Matkin, G.S., Burbach, M.E., Quinn, C.E., Harding, H. (2012)	Educational Philosophy and Theory 44(2), pp. 212-230	80
Lee, H., Parsons, D., Kwon, G., (...), Jeong, E., Ryu, H. (2016)	Computers and Education 97, pp. 97-115	78
Kong, S.C. (2015)	Computers and Education 89, pp. 16-31	78
Loes, C., Pascarella, E., Umbach, P. (2012)	Journal of Higher Education 83(1), pp. 1-25	71
Changwong, K., Sukkamart, A., Sisan, B. (2018)	Journal of International Studies 11(2), pp. 37-48	65
Naber, J., Wyatt, T.H. (2014)	Nurse Education Today 34(1), pp. 67-72	62

From the most cited critical thinking topics, namely regarding critical thinking, critical thinking skills such as 5 articles/journals with the top article excerpts written by Kong, S.C. (2014), Fuad, N.M., Zubaidah, S., Mahanal, S., Suarsini, E. (2017), Niu, L., Behar-Horenstein, L.S., Garvan, C.W. (2013), Duran, M., Dökme, I. (2016), and Flores, K.L., Matkin, G.S., Burbach, M.E., Quinn, C.E., Harding, H. (2012).

Publication Pattern: Source Title (Journal or Proceedings)

The journals and proceedings that have contributed the most to research on critical thinking skills in the 2012-2022 range are depicted in Table 3. The Journal of physics conference series is a series of leading conferences that contain articles on critical thinking. Meanwhile, the international journal of instruction, Indonesian science education journal, universal journal of educational research, and European journal of educational research are leading journals that discuss critical thinking in their content. The remaining journals are AIP conference proceedings, IOP conference series earth and environmental science, thinking skills and creativity, nurse education today, ACM international conference proceedings series.

Table 4. Number of Research Documents on Critical Thinking Ability (2012-2022) Across Source Titles

No	Source Title	Number of Documents
1	Journal of Physics Conference Series	293
2	AIP Conference Proceeding	59
3	International Journal of Instruction	33
4	Jurnal Pendidikan IPA Indonesia	20
5	Universal Journal of Educational Research	18
6	IOP Conference Series Earth and Environmental Science	16
7	Thinking Skills and Creativity	16
8	Nurse Education Today	14
9	ACM International Conference Proceeding Series	11
10	European Journal of Educational Research	11

Visualization of Research Trends on critical thinking topics in physics argumentation Based on VOSViewer Software

The data found were 1063 documents related to critical thinking in the Scopus database, which were used by researchers to visualize research trends on this topic using the help of VOSViewer. This method is used to help find research novelty in this domain. The overall picture of research on critical thinking skills can be seen in Figure 9. Researchers in the world produced 3 primary clusters marked with red, green and blue and one secondary cluster marked with yellow as done by (Tupan et al., 2018) which says that in the density visualization there are several areas marked in yellow, green and blue which indicate each region obtained.

The first cluster that is red in color includes courses that are used to improve critical thinking processes, what knowledge is in critical thinking skills, and everything that includes how to improve critical thinking

skills from various perspectives. The second green cluster is an instrument used to improve critical thinking skills. The third cluster in blue is a group that needs to be controlled to improve critical thinking skills. Finally, the fourth cluster, namely yellow, includes the effect of gender on increasing critical thinking skills.

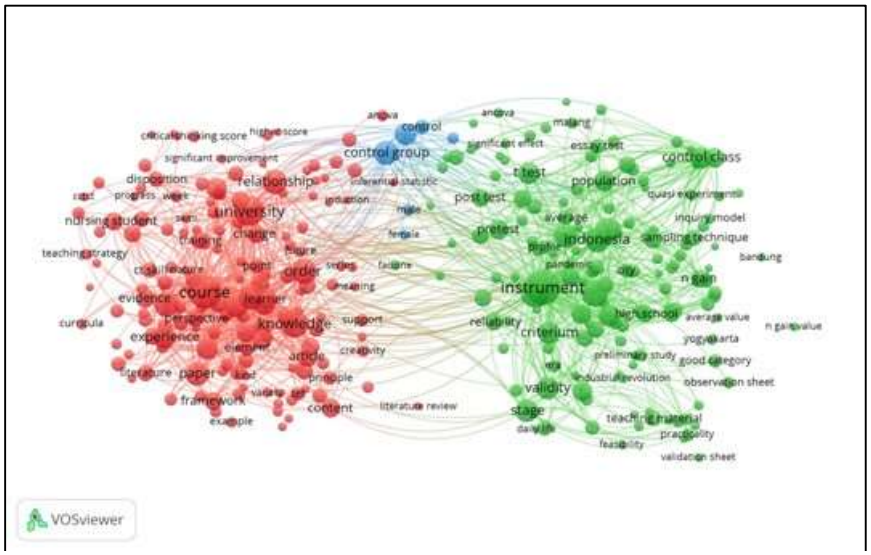

Figure 9. Overall Figure of Research on Critical Thinking Ability 2012-2022

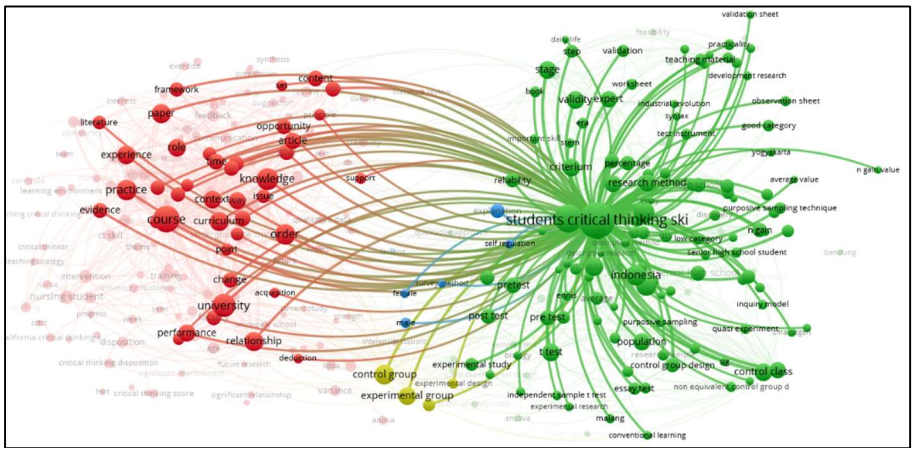

Figure 10. Critical Thinking Network a Number of Research in the Domain of Higher-Order Thinking Skills from 2010-2020 Based on Scopus data

It can be seen in Figure 10 that the topic of critical thinking is widely used in research, both in the form of journals and articles. A lot of critical thinking research has been carried out because in solving real life critical thinking skills are needed which are included in 21st century skills, this research is supported by research by (Jannah & Atmojo, 2022). And also, as said by (Munawwarah et al., 2020), critical thinking is emphasized in 21st century learning and teachers are expected to develop their critical thinking skills at any time in the learning process in the classroom.

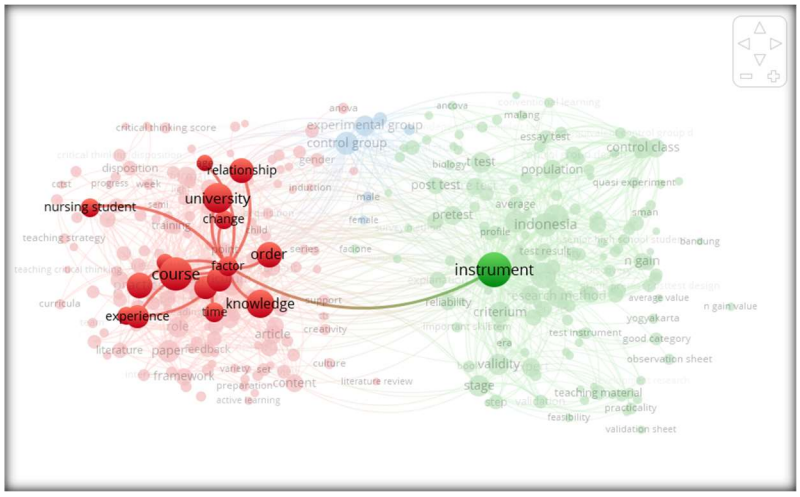

Figure 11. Factors that Influence the Level of Critical Thinking Skills

Training that can improve critical thinking can be explained by Figure 12. Where there are several elements of words contained in the realm of training (course), namely knowledge, perspective, experience, role, change. change). Where the word knowledge (knowledge) is meant in the process of critical thinking, when involved in a topic can solve or predict possibilities based on what is known before. For perspective (point of view) where this ability is to assess or evaluate something based on each point of view. Experience (experience) the ability to raise ideas, or explain about an object, event, or one's own experience. The role for this process is to find a solution or way out of the problem he encounters on his own. As for change (change) where we can make a change from the process of critical thinking.

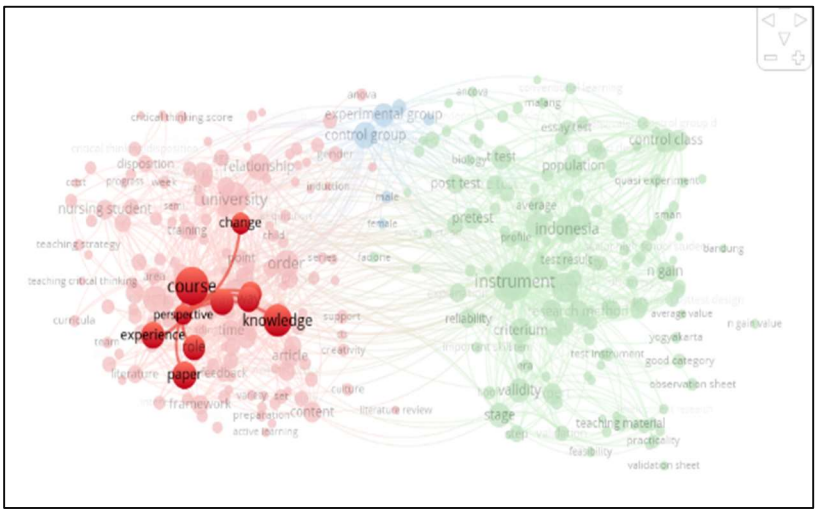

Figure 12. Any Training to Improve One's Ability to Think Critically

Figure 13 illustrates the network map of keyword relationships in critical thinking disposition generated using VOSviewer. The visualization reveals two major clusters: the red cluster, which emphasizes themes such as *course, practice, university, performance, relationship, nursing student,* and *critical thinking disposition*, indicating a strong focus on educational contexts and learner characteristics; and the green cluster, which highlights keywords like *validity, research method, indicator, test, control class,* and *population*, reflecting methodological approaches and assessment frameworks commonly applied in critical thinking research. The size of each node represents the frequency of keyword occurrence, while the links between nodes indicate the strength of co-occurrence in the literature. This map demonstrates how research on critical thinking disposition is situated within both pedagogical practices and empirical validation processes, suggesting a balanced integration between instructional contexts and research methodology.

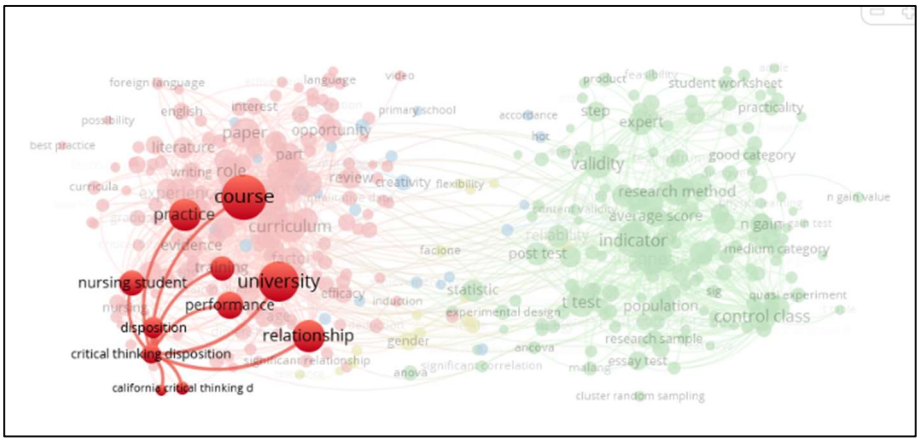

Figure 13. Network Map of Keyword Relationships in Critical thinking Disposition

Figure 14 explains what indicators are contained in the research on critical thinking skills. Where are the indicators contained in research on critical thinking skills, there are research methods, population, validity, control class, observation sheets, student worksheets, n -gain, t-test. This means that in research on critical thinking skills it is better to use the indicators that have been mentioned so that they become the correct arrangement of articles.

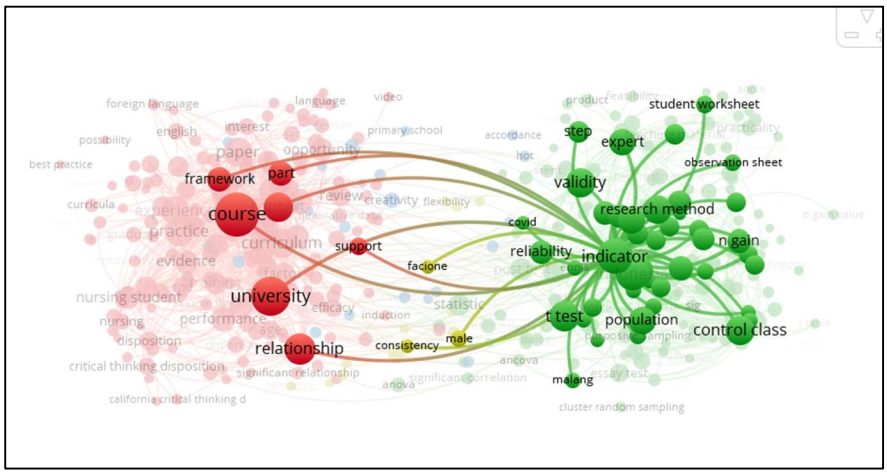

Figure 14. Indicators in the Preparation of Articles about Critical Thinking Skills

Figure 15 illustrates research methods in researching critical thinking skills such as learning models, way, expert, control class, explanation, medium category, validation, sampling technique, good category, book, junior high school, elementary school. This means that research on critical thinking skills uses both quantitative and qualitative paradigms.

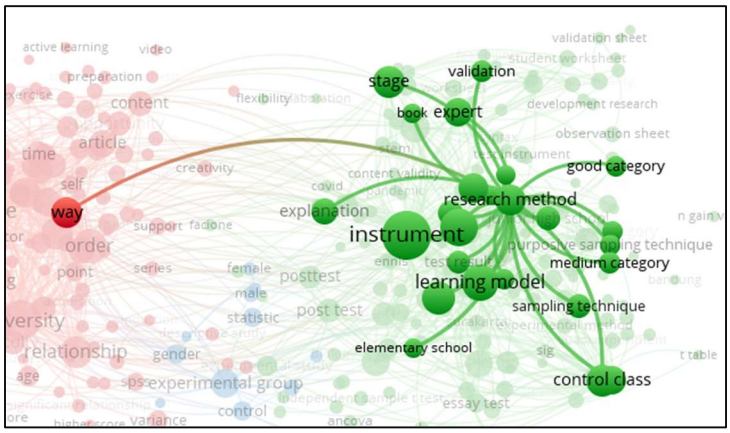

Figure 15. Research Methods in Critical Thinking Skills Research

In data collection, the instruments used in researching critical thinking skills are essay tests, posttests, student worksheets, development research, experimental methods, surveys (figure 16). Furthermore, the Indonesian term also dominates as a keyword in research on critical thinking skills (figure 17).

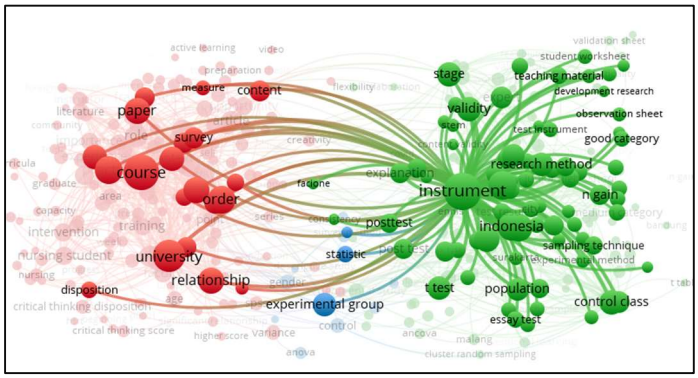

Figure 16. Critical Thinking Ability Research Instrument

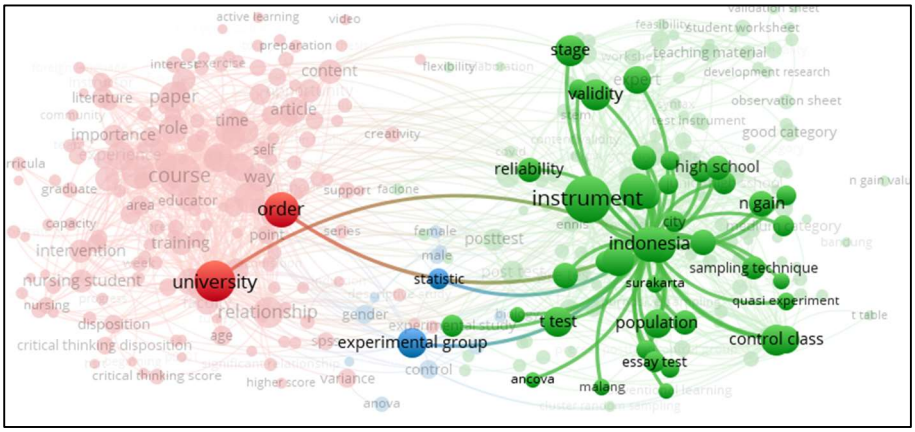

Figure 17. Indonesia Dominates the Search for Keywords about Critical Thinking Skills

The Contribution of Indonesian Researchers in Researching Critical Thinking Skills

Table 5 describes the ranking of Indonesian institutions in producing documents on research on critical thinking skills. Meanwhile, table 6 shows that Indonesia's contribution in researching critical thinking skills is more in proceedings than journals.

Table 5. Number of Documents on Critical Thinking Skills among Indonesian Institutions (2012-2022)

No	Affiliation	Number of Documents
1	Universitas Pendidikan Indonesia	82
2	Universitas Negeri Malang	74
3	Universitas Sebelas Maret	64
4	Universitas Negeri Yogyakarta	51
5	Universitas Negeri Surabaya	34
6	Universitas Negeri Jakarta	26
7	Universitas Negeri Semarang	23
8	Universitas Jember	21
9	Universitas Lampung	18

Table 6. Number of Documents on Critical Thinking Skills from Indonesia (2012-2022) across Source Titles

No	Source Title	Number of Documents
1	Journal of Physics Conference Series	293
2	AIP Conference Proceedings	59
3	International Journal of Instruction	33
4	Jurnal Pendidikan IPA Indonesia	20
5	Universal Journal of Educational Research	18
6	IOP Conference Series Earth and Environmental Science	16
7	Thinking Skills and Creativity	16
8	Nurse Education Today	14
9	ACM International Conference Proceeding Series	11

CONCLUSION

In this paper, the research method used is bibliometrics to study the state of research in a particular field of knowledge. The focus of this study is the development of articles on critical thinking skills, the most active researchers, the countries and institutions where the research is conducted, and the primary sources where the papers are published. Research on critical thinking skills has developed significantly every year, although there was a decline during 2020–2021. The distribution of research publications across countries is dominated by Indonesia, which produced a total of 557 documents and positioned the Indonesian University of Education as the top institution contributing the most documents on critical thinking skills. Indonesia also contributed the most productive author in this field, namely Zubaidah, S., who ranked first as the leading author. The visualization of research trends on critical thinking skills generated one minor cluster (yellow) and three major clusters (red, green, and blue), which consist of: (1) factors that influence critical thinking skills, (2) training in the process of critical thinking skills, (3) critical thinking disposition, (4) research methods on critical thinking skills, and (5) instruments for assessing critical thinking skills. These findings can help researchers recognize global research trends on critical thinking skills and provide future research directions. In addition, the results of this study contribute to physics education by offering insights into how critical thinking skills can be systematically integrated into physics learning, particularly in enhancing problem-solving, reasoning, and conceptual understanding. For future research, it is recommended to expand bibliometric studies to more specific contexts such as physics subfields, digital learning environments, and cross-disciplinary collaborations to further strengthen the application of critical thinking in education.

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AUTHOR CONTRIBUTIONS

Indah Wulandari: Conceptualization, Methodology, Writing - Original Draft, and Writing - Review & Editing; **Julianto:** Validation and Supervision; **Faiz Hasyim:** Validation and Supervision; and **Setyo Admoko**: Validation, Supervision, dan Project Administration. All authors have read and approved the final version of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no financial conflicts of interest or personal relationships that could have influenced the results reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript have complied with ethical standards for research and publication, are in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that Generative Artificial Intelligence (GAI) and other assistive technologies were not extensively used in the research and writing of this manuscript. Specifically, ChatGPT was used for brainstorming. The authors have reviewed and edited all AI-generated content for accuracy, completeness, and adherence to ethical and scientific standards, and take full responsibility for the final version of the manuscript.

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