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Critical Thinking Measurement Methods in Higher Education: A Bibliometric Analysis

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Abstract

Critical thinking skills are crucial in modern society. This research aims to provide a general overview of recent developments in research methods for measuring critical thinking skills in higher education. It is based on a bibliometric analysis of journal articles published in the Scopus database, with the goal of identifying scientific gaps and providing a reference for further research. The methodology employed includes bibliometric analysis using VOSviewer and Biblioshiny software. The results indicated a growing trend in research focused on measuring critical thinking skills. Several topics and keywords have emerged that could serve as a foundation for future studies, along with trends in research methods for assessing critical thinking skills in higher education. The research concluded that bibliometric analysis offers valuable insights into developing research on measuring critical thinking and its methods, paving the way for further investigations. Notably, topics related to undergraduate students, critical thinking skills, and active learning potentially yield significant novel contributions if explored in future research.

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INTRODUCTION

Natural Sciences have great potential in preparing human resources who think critically, logically, and creatively in responding to current developments (Dekker, 2020; Sutoyo et al., 2023). Science as a scientific discipline that relies on students' thinking processes contains aspects that substantially guide students to think logically so that they can filter information, decide whether the information suits their needs, and question the truth of information which is sometimes shrouded in lies. In science learning, students not only know and understand the knowledge they have acquired, but students are also required to think critically, logically and precisely (Rudolph & Horibe, 2016).

The capacity for critical thought is one of the important thinking skills in modern society (Ennis, 2018). The capacity to recall, scrutinize, acquire, apply, draw conclusions, synthesize, and evaluate information is known as critical thinking. Lai (Rizky & Sritresna, 2021) lists the following as indicators of critical thinking skills: evaluating or passing judgment, dissecting arguments, drawing findings using inductive or deductive reasoning, and solving issues or coming to conclusions. From the definitions outlined previously, it can be concluded that critical thinking skills can prepare students to develop their potential (Lithoxoidou & Georgiadou, 2023).

Indonesian students still struggle with critical thinking. Students have not actively participated in science learning, which is one of the factors contributing to their deficient critical thinking skills. If students are active in learning, such as actively asking questions or giving opinions, students critical thinking skills can increase and science learning goes well (Ivancu et al., 2023; Mulyono et al., 2023; Payan-Carreira et al., 2022). To improve students' critical thinking skills in learning, an efficient learning framework is required. The learning model is applied so that learning objectives are achieved and improve students' critical thinking skills. However, there are several learning models implemented by teachers that do not involve active participation from students and the mathematics problems that teachers give to students do not allow students to solve them in different and systematic ways (Ariyatun, 2021).

Many studies have been conducted regarding critical thinking skills in learning. Therefore, researchers want to know and analyze research developments that discuss measuring critical thinking skills in research that has been carried out in the 2021-2023 range. Based on the background description above, the researcher conducted research using a Systematic Literature Review (SLR). In addition to describing research trends connected to evaluating critical thinking skills in 2021–2023, this study attempts to describe the research methodologies utilized in measuring critical thinking skills at the tertiary level. Based on this objective, the following research questions guide the current research, namely: (1) what is the output profile of critical thinking publications in 2021-2023? (2) how to visualize the results of critical thinking research trends for 2021-2023?; and (3) what methods are used to measure critical thinking in research in 2021-2023?

METHODS

A general scientific mapping procedure comprising five phases was employed in this study: (1) Study Design, (2) Data Collection, (3) Data Analysis, (4) Data Visualization, and (5) Interpretation (Börner et al., 2005; Zupic & Čater, 2015). During the study design phase, the primary research question was: Which research papers on efficiency measurement in higher education using the Data Envelopment Analysis (DEA) approach are indexed in the Scopus database?

The data collection phase consists of three substages: data gathering, data filtering, and data cleaning. The data were gathered using the advanced search capabilities of the Scopus database (http://www.scopus.com); the authors inserted search terms and matching operators according to the search engine's syntax. The search keywords were divided into three parts: (1) Terms related to effectiveness and performance, such as "performance," "measurement performance," and "efficiency."; (2)Terms associated with higher education, such as "universities," "higher education," and "higher public education."; (3) The term "data envelopment analysis" (DEA). The researchers combined these keywords using OR and AND operators, searching within the papers'

abstract, keywords, and title. The search was restricted to documents classified as articles, conference papers, book chapters, and reviews, all written in English and categorized under social sciences. These stages are visualized in Figure 1.

Determining Searching Keyword

The keywords used for this research were ((critical thinking OR "measurement critical thinking") AND (university OR "higher education" OR "higher public education"))

Articles were limited to those published in journals from 2013 to 2023. The chosen database was Scopus, with the subject area restricted to the field of social sciences. To ensure high-quality publications, articles from the Scopus database, which includes a range of publishers such as Elsevier, Springer, Wiley, Taylor & Francis, Emerald, Nature, and others, were selected.

Initial Searching Results

A direct search was conducted via the Scopus website using the publication year filter from 2018 to 2023, yielding 421 documents. Further refining the search to the publication years 2021 to 2023 resulted in 280 documents. The article data for the years 2021-2023 were saved in CSV format.

Filtering the Searching Results

The collected article data were initially stored in CSV files and reviewed using Mendeley reference management software. Based on the analysis requirements and research objectives, the journal data were then processed and filtered.

Collecting and Compiling the Statistics of Searching Results

After filtering and processing the article data, statistics were compiled, including the top 10 most-cited articles, the top 10 publishers and journals, and the evolution of articles over the previous three years (2021–2023). This information was used for further analysis.

Performing Data Analysis

Bibliometric analysis was conducted using VOSviewer version 1.6.19 and Biblioshiny software. VOSviewer offers engaging and interactive tools for data visualization and analysis and is adept at handling large volumes of data (van Eck & Waltman, 2010). Then, VOSviewer can create author, journal, or publication maps using co-citation networks. It can also show keyword maps derived from shared networks (Arisoy & Aybek, 2021; O'Reilly et al., 2022; Raj et al., 2022). For analysis, VOSviewer's co-authorship type and full counting method were applied with a maximum of 25 authors per document and a minimum of 2 documents per author. Additionally, VOSviewer analysis utilized text data and the full counting approach, with a minimum of 15 term occurrences.

Biblioshiny was used to evaluate data in a CSV file extension format. The first analysis includes plotting and analysis for three distinct level metrics (document source, author, and article document). The second type of analysis examines three knowledge structures: social, conceptual, and intellectual structures. The analytical results obtained from the VosViewer and Biblioshiny software are described descriptively using maps and visualizations.

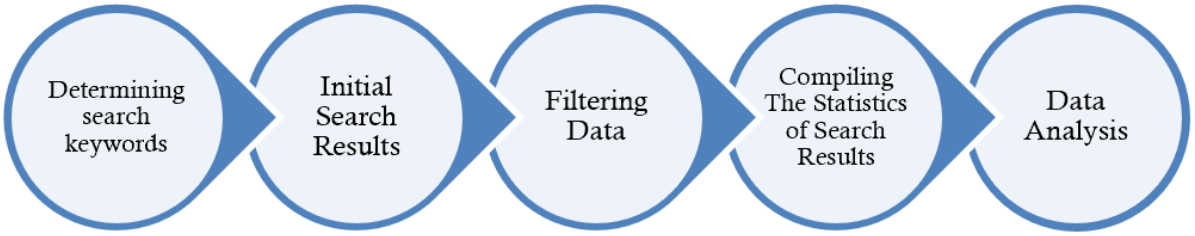

Figure 1. Bibliometric Research Stages

RESULTS AND DISCUSSION

Primary Information

In this section, the researchers examined the growth of scientific publications related to measuring critical thinking at the higher education level globally. These publications were analyzed by year, core journals were identified, and the number of publications by institution/affiliation, country, subject, and document type ranged from 2021 to 2023. The document type analyzed for this research is articles, totalling 280 in number. The data revealed that scientific publications on critical thinking have an average of 3,561 citations per document and include 13,130 references. Additionally, there are 873 documents with multiple authors, while 42 documents with single authors. The percentage of international co-authorship stands at 18.21%.

Over the past three years, published articles have consistently increased. In 2021, 83 articles were published, marking the baseline of the collected data. The number of articles rose to 92 in 2022, reflecting an increase of 9 articles, or approximately 10.84%, compared to the previous year. This upward trend continued into 2023, with the number of articles reaching 105, representing a 13-article increase, or around 14.13%, compared to 2022. Overall, from 2021 to 2023, there was an increase of 22 articles or about 26.51%. This growth may indicate various factors, such as heightened writing and publication activity, growing interest in specific topics, or incentives or policies promoting more active publishing. Regarding the journals in which these articles were published, there are ten key sources where articles on critical thinking have appeared (see Table 1).

Table 1. Most Relevant Sources

Sources	Articles
Education Sciences	26
Sustainability (Switzerland)	24
Frontiers In Education	12
Bmc Medical Education	11
Thinking Skills And Creativity	8
Journal of Higher Education Theory And Practice	5
International Journal of Emerging Technologies In Learning	4
International Journal of Instruction	4
Nurse Education Today	4
Critical Studies In Teaching And Learning	3
International Journal of Chinese Education	3
International Journal of Educational Research Open	3
International Journal of Evaluation And Research In Education	3
International Journal Of Learning, Teaching And Educational Research	3
Journal of Food Science Education	3
Journal of Teaching English For Specific And Academic Purposes	3
Revista De Ciencias Sociales	3
Teaching And Learning Inquiry	3
Cogent Education	2

Analysis of Co-Word

Co-occurrence mapping of significant or specific phrases found in particular articles is based on co-word analysis based on keywords (Dumitru et al., 2023; Sugrah et al., 2023). Science mapping is a bibliometric visualization technique used to depict scientific fields. This approach creates a landscape map to visualize scientific topics. VOSviewer displays up to 149 terms related to assessing critical thinking, each with at least 15 occurrences. By default, VOSviewer displays 60% of these terms.

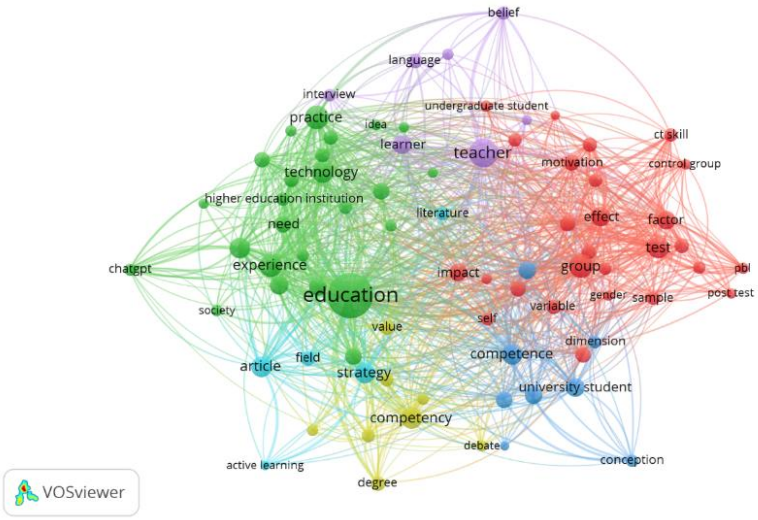

Figure 2. Network Visualization with Critical Thinking

The density visualization of research related to critical thinking, resulting from VOSviewer analysis, is shown in Figure 5. Density visualization illustrates the intensity of research focus within different groups. It can help identify research topics that are still underexplored (Badeo & Duque, 2022). A brighter yellow colour indicates that a topic has been explored frequently or very frequently, while more faded or fuzzy colours suggest that the terms, keywords, or themes are less researched. The themes highlighted in white in Figure 5 represent areas still relatively underexplored, as indicated by the nearly lost underlying colour. This suggests that topics such as undergraduate students, critical thinking abilities, and active learning may offer opportunities for highly novel research if further studies are conducted.

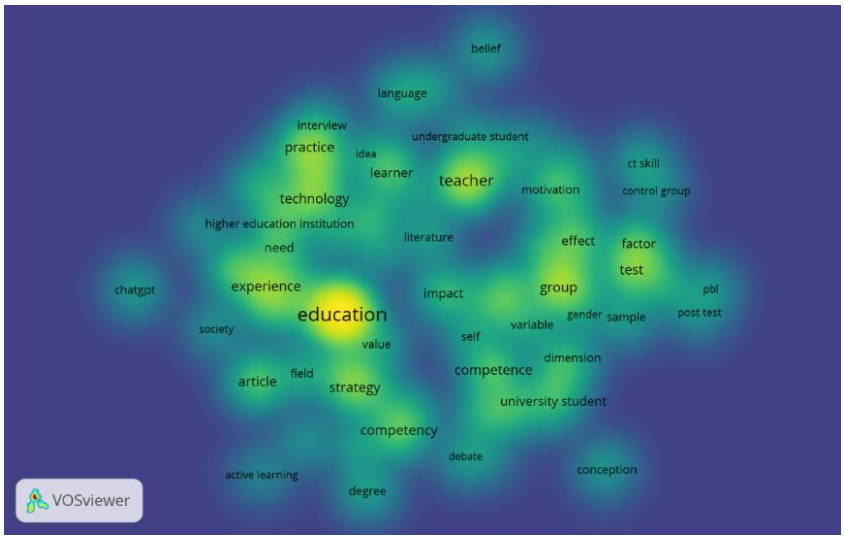

Figure 3. Density Visualization of Critical Thinking

Most Relevant Research Methods

After analyzing annual scientific production, key affiliations, significant sources, and co-word analysis, potential topics with novelty were identified. Following this, mapping and analysis were conducted to evaluate the research methods used in measuring critical thinking at the university level. To facilitate this analysis, 15 articles were selected, and their data is presented in Table 3.

Table 3. Mapping of Research Methods for Measuring Critical Thinking

Article Title	Year	Method
Development of the Perception of Achievement of Complex Thinking: A Disciplinary Approach in a Latin American Student Population	2022	Conducted a statistical analysis to obtain the mean, variance, scale impact, and relative dispersion, and we performed significance tests
Overcoming Essentialism? Students' Reflections on Learning Intercultural Communication Online	2022	Qualitative case study.
Higher Education Faculty Perceptions and Needs on Neuroeducation in Teaching and Learning	2022	Mixed research method
Harnessing Project-Based Learning to Enhance STEM Students' Critical Thinking Skills Using Water Treatment Activity	2022	An action research design
Development and Validation of a Critical Thinking Assessment-Scale Short Form	2022	The confirmatory analysis
Methodologies for Fostering Critical Thinking Skills from University Students' Points of View	2023	An ad-hoc online survey
Viewpoints on the Development of Critical Thinking Skills in the Process of Foreign Language Teaching in Higher Education and the Labor Market	2023	Observation, focus groups and documentary analysis
Implementation of the Critical Thinking Blended Apprenticeship Curricula and Findings per Discipline: Foreign Language Teaching	2023	Quantitative and qualitative methods of research.
Undergraduate Students' Conceptualization of Critical Thinking and Their Ideas for Critical Thinking Acquisition	2023	A mapping study of students' ideas regarding critical thinking (CT)
Developing Critical Thinking in Technical and Vocational Education and Training	2023	Experimental Design
A Model for the Selection of Active Learning While Taking into Account Modern Student Behavior Styles	2023	An online survey
The Task-Based Approach to Teaching Critical Thinking for Computer Science Students	2023	Experimental Design
The Role of Intangible Heritage in Critical Citizenship	2023	Case study

Article Title	Year	Method
Education: An Action Research Case Study with Student Primary Education Teachers		
Challenges and Opportunities of Generative AI for Higher Education as Explained by Chat GPT	2023	A thing ethnography approach
Chat GPT and Generative AI: Possibilities for Its Contribution to Lesson Planning, Critical Thinking, and Openness in Teacher Education	2023	Qualitative approach and document analysis

Table 3 illustrates various research methods to measure critical thinking in higher education and related studies. Qualitative methods, such as case studies and ethnographic approaches, are frequently used to gain an in-depth understanding of subjects' perceptions and experiences. Quantitative methods, including experimental designs and surveys, gather data that can be measured and analyzed statistically. Additionally, mixed methods approaches are commonly applied, combining elements of both quantitative and qualitative methods to yield more comprehensive results. For example, the article "The Role of Intangible Heritage in Critical Citizenship Education" employs a case study method to explore how critical citizenship education can be taught to pre-service elementary education teachers. The article "The Task-Based Approach to Teaching Critical Thinking for Computer Science Students" uses an experimental design to assess the effectiveness of a task-based approach in teaching critical thinking. Another study, "A Model for the Selection of Active Learning While Taking into Account Modern Student Behavior Styles," utilizes online surveys to collect data on student profiles, teaching methods, and learning behavioural styles. Additionally, confirmatory and statistical analyses are employed in studies such as "Development and Validation of a Critical Thinking Assessment-Scale Short Form" to test the reliability of measurement instruments. Overall, Table 3 provides an overview of the diverse methodological approaches used to assess critical thinking, highlighting the flexibility and breadth of research in this area.

CONCLUSION

From 2021 to 2023, there has been a general upward trend in scientific advancements related to critical thinking assessment. Co-authorship and co-word analyses, conducted using VOSviewer, are examples of bibliometric analyses that provide insights into research developments. This analysis generated several keywords and themes that could serve as a foundation for further investigation. Research focusing on undergraduate students, critical thinking abilities, and active learning holds the potential for highly innovative findings. To refine and expand upon the literature review results, it is recommended to use a more extensive, more reliable database and carefully select keywords. Additionally, advanced tools and software, such as Citespace, should be employed. Citespace offers features such as visual exploration of a research field, structural and temporal overviews, identification of hot topics and emerging trends, cascading citation expansion, systematic visual analysis of scientific literature, and monitoring scientific developments in research topics.

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